

SECTION 23 05 00

GENERAL HVAC REQUIREMENTS

PART 1 GENERAL

1.01 SCOPE

- A. Furnish and install a complete building HVAC system as per drawings and enclosed specifications. Provide a competent supervisor, foreman, etc. to expedite all phases of the HVAC Project.
- B. Requirements specified herein shall govern applicable portions of all mechanical work sections, whether so stated therein or not. Where items specified in mechanical work sections conflict with requirements in this specification, the former shall govern.
- C. Heating Contractor shall provide temporary heating devices as needed until new building heating system is operational, and can be used to maintain minimum temperatures in new construction.
- D. Job site to be seen to ascertain existing field conditions. Failure to visit the job site does not limit the contractual responsibility of any aspect of the HVAC project.
- E. Items To Include:
 - 1. Scope
 - 2. Abbreviations
 - 3. References
 - 4. Definitions
 - 5. Quality Assurance
 - 6. Shop Drawings, Wiring Diagrams and Descriptive Data
 - 7. Substitution of Equipment and Materials
 - 8. Related work of Mechanical Trades
 - 9. Electrical Requirements and Provisions
 - 10. Coordination
 - 11. Temporary Services
 - 12. Codes, Permits and Fees
 - 13. Transportation, Storage and Protection of Equipment and Materials
 - 14. Materials and Equipment Installation
 - 15. Existing Equipment
 - 16. Demolition
 - 17. Sleeves, and Openings
 - 18. Flashing
 - 19. Sealing and Fire stopping
 - 20. Cutting and Patching, Holes and Sleeves
 - 21. Equipment Access
 - 22. General Pressure Piping Specification

- 1 23. Painting
- 2 24. Trenching and Backfilling
- 3 25. Inspection and Tests
- 4 26. Cleaning and Flushing
- 5 27. Operating Test
- 6 28. Operation and Maintenance Manuals
- 7 29. Record Drawings
- 8 30. Identification
- 9 31. Testing and Balancing
- 10 32. HVAC System Commissioning

11 1.02 ABBREVIATIONS

- 12 A. The following abbreviations are used throughout all mechanical work sections.
- 13 1. amp ampere
 - 14 2. bhp brake horsepower
 - 15 3. Btu British Thermal Unit
 - 16 4. c to c center to center or on center
 - 17 5. cfm cubic feet per minute
 - 18 6. deg degree (angle)
 - 19 7. F degree Fahrenheit
 - 20 8. fpm feet per minute
 - 21 9. ft. foot
 - 22 10. gal gallon
 - 23 11. gph gallons per hour
 - 24 12. gpm gallons per minute
 - 25 13. hp horsepower
 - 26 14. hr hour
 - 27 15. in. or " inch
 - 28 16. ID inside diameter
 - 29 17. ips iron pipe size
 - 30 18. kw kilowatt
 - 31 19. max maximum
 - 32 20. min minimum
 - 33 21. oz ounce
 - 34 22. OD outside diameter
 - 35 23. os & y outside screw & yoke
 - 36 24. lb. pound
 - 37 25. psi pounds per square inch
 - 38 26. rpm revolutions per minute
 - 39 27. sec second
 - 40 28. std standard
 - 41 29. sp static pressure
 - 42 30. temp temperature
 - 43 31. wwp water working pressure

44 1.03 REFERENCES

1 A. References to standards, codes or specifications shall mean the latest edition of
2 such publication adopted and published at date of invitation to submit proposals.

3 B. References to technical societies, trade organizations and governmental agencies
4 are made in accordance with the following abbreviations.

- | | | | |
|----|-----|------------|---|
| 5 | 1. | AFI | Air Filter Institute |
| 6 | 2. | AGA | American Gas Association, Inc. |
| 7 | 3. | ANSI | American National Standards Institute |
| 8 | 4. | ASHRAE | Amer. Society of Heating, Refrigeration & Air |
| 9 | | | Conditioning Engineers |
| 10 | 5. | ASME | American Society of Mechanical Engineers |
| 11 | 6. | AMCA | Air Moving & Conditioning Association, Inc |
| 12 | 7. | ASTM | American Society for Testing Materials |
| 13 | 8. | AWWA | American Water Works Association |
| 14 | 9. | BOCA | Building Officials and Code Administrators |
| 15 | 10. | CS | Commercial Standard |
| 16 | 11. | FM | Factory Mutual |
| 17 | 12. | IBR | Institute of Boiler & Radiator Manufacturers |
| 18 | 13. | IRI | Industrial Risk Insured |
| 19 | 14. | ISOW | Insurance Services of Wisconsin |
| 20 | 15. | NAFM | National Association of Fan Manufacturers |
| 21 | 16. | NFPA | National Fire Protection Association |
| 22 | 17. | NBS | National Bureau of Standards |
| 23 | 18. | PDI | Plumbing and Drainage Institute |
| 24 | 19. | SBI | Steel Boiler Institute |
| 25 | 20. | SMACNA | Sheet Metal & Air Conditioning Contractors National |
| 26 | | Assoc. Inc | |
| 27 | 21. | UL | Underwriter's Laboratories, Inc |

28 1.04 DEFINITIONS

29 A. The following are definitions of terms and expressions used in mechanical work
30 Sections.

- | | | | |
|----|----|------------------|--|
| 31 | 1. | <u>Provide</u> | means furnish and install in place. |
| 32 | 2. | <u>Herein</u> | means contents of a particular section where this term appears. |
| 33 | 3. | <u>Indicated</u> | means indicated on contract drawings. |
| 34 | 4. | <u>Section</u> | denotes "trade section" or basic unit of work. |
| 35 | 5. | <u>Division</u> | denotes a group of related sections. All Mechanical Work falls |
| 36 | | | into Division 23. |
| 37 | 6. | <u>Concealed</u> | means any pipe, duct, conduit or accessories hidden from sight |
| 38 | | | as in trenches, chases, furred spaces, pipe shafts or hung ceilings. |
| 39 | 7. | <u>Exposed</u> | means they are "not concealed" as defined herein above. |
| 40 | 8. | <u>Piping</u> | includes in addition to pipe, fittings, valves, hangers and |
| 41 | | | accessories. |

42 1.05 QUALITY ASSURANCE

1 A. Comply with manufacturer's instructions in full detail, including each step in
2 sequence. Should instructions conflict with contract documents, request
3 clarification from Architect/Engineer before proceeding.

4 B. Where equipment or accessories are used which differ in arrangement,
5 configuration, dimensions, ratings, or engineering parameters from those
6 indicated in the contract documents, the contractor is responsible for all costs
7 involved in integrating the equipment or accessories into the system and for
8 obtaining the performance from the system into which these items are placed.
9 This may include changes found necessary during the testing, adjusting and
10 balancing phase of the project.

11 1.06 SHOP DRAWINGS, WIRING DIAGRAMS AND DESCRIPTIVE DATA

12 A. Submit shop drawings, wiring diagrams and descriptive data on all equipment,
13 apparatus, fixtures and specialties to be provided. Manufacturer shall prepare
14 these drawings or his franchised dealer for this specific installation unless
15 equipment is stock design then standard shop drawing may be submitted.
16 Drawings shall show all physical sizes and required services, installation
17 instructions, description of operation including recommended testing and
18 adjusting procedures shall be included.

19 1.07 SUBSTITUTION OF EQUIPMENT AND MATERIALS

20 A. Assume all responsibility for any and all changes made to the HVAC system due
21 to substitutions. Manufacturers listed first in the Specifications were used in
22 preparing the drawings. Other Manufacturers listed are considered substitutions,
23 but may be submitted for approval as potentially equal to the initial manufacturer
24 identified. Manufacturers not listed in the Specification will not be considered
25 "As Equal" to the design equipment or material.

26 B. Notify all Contractors of substitutions made prior to their involvement with the
27 substitution installation. Provide all modifications to ductwork and other
28 Construction necessary due to substitutions. Equipment must be accessible for
29 servicing filters, bearings, motors, belts, etc.

30 1.08 RELATED WORK OF MECHANICAL TRADES

31 A. The following tabulation of items of work are not all inclusive but are set forth to
32 establish a pattern to be maintained should items occur which are not specifically
33 covered in the various divisions of the work.
34 1. Plumbing - Any equipment provided by other trades requiring water,
35 compressed air or drainage piping thereto shall have these services
36 provided by that other Trade. Provide a gate valve or stop valve and union
37 at point of connection to such equipment. Provide traps and vents or open
38 sight drains to satisfy drainage requirements of equipment.

2. Heating - Any equipment provided by other trades requiring steam, hot water, or condensate thereto shall have these services provide by that other Trade. Provide traps and vents to satisfy condensate drainage requirements of equipment using steam.

a. If regulators or mechanical devices for control of services are necessary, Contractor supplying equipment for installation by this Contractor shall furnish these items.

b. Gas piping shall be specified in plumbing or heating. Contractor whose scope of work includes gas piping will serve all equipment requiring gas. Special valves, pressure-regulators, etc., if required, will be provided with equipment.

B. Ventilating and Air Conditioning - Provide sheet metal vents or ducts on any equipment furnished by other trades making final connection thereto using flexible connectors in case of ductwork only. Install pre-heat and/or re-heat coils furnished by others. Install temperature control dampers.

C. Refrigeration - Provide piping to cooling coils.

D. Temperature Controls - Any equipment provided by other trades requiring temperature control work shall be provided by this Contractor unless specifically exempted in specifications. Provide schematic diagrams as specified and include pneumatic or electrical work necessary to connect all components to function as a complete system. The Temperature Controls Contractor shall wire control wiring specified in Temperature Control Section.

1.09 ELECTRICAL REQUIREMENTS AND PROVISIONS

A. For electrically operated equipment provide all motors. Starters, controllers, and disconnects which are an integral part of unit equipment shall be provided with that equipment. All other HVAC related starters and controllers which are not included as part of the equipment shall be provided by the heating contractor and installed by the electrical contractor. All control devices and sensors associated with the electrically operated equipment shall be provided as part of heating contract, unless otherwise indicated. Deliver starters to Electrical contractor for installation.

B. The electrical contractor shall furnish all fused and/or circuit breaker disconnect switches.

1.10 COORDINATION

A. Verify that all devices are compatible for the surfaces on which they will be used. This includes, but is not limited to, diffusers, registers, grilles and recessed or semi-recessed heating and/or cooling terminal units installed in/on architectural surfaces.

- 1 B. Coordinate all work with other contractors prior to installation. Any installed
2 work that is not coordinated and that interferes with other contractor's work shall
3 be removed or relocated at the installing contractor's expense.

4 1.11 TEMPORARY SERVICES

- 5 A. Whenever temporary services are required to maintain operation of equipment, it
6 is understood that the Contractors responsible for final connections to permanent
7 services shall do this temporary work. All temporary material shall be removed
8 after it has served its use. See Special Conditions for temporary services required
9 during construction of project.

10 1.12 CODES, PERMITS AND FEES

- 11 A. All Mechanical work shall conform with all Federal, State and Local Codes and
12 regulations. If codes or regulations conflict, the most stringent shall apply.
13 Permits and inspection fees are to be secured in fulfilling the requirements of
14 these Specifications.

15 1.13 TRANSPORTATION, STORAGE AND PROTECTION OF EQUIPMENT AND
16 MATERIALS

- 17 A. Transport and handle equipment by methods to avoid damage. Promptly inspect
18 shipments to assure that equipment complies with requirements, quantities are
19 correct and equipment is undamaged.
- 20 B. Cover equipment and materials to eliminate rust and corrosion while allowing
21 sufficient ventilation to avoid condensation. Do not store materials directly on
22 grade. Protect pipe, tube and fitting ends to avoid damage.
- 23 C. Provide access for inspection of all stored equipment. Periodically inspect to
24 assure equipment is undamaged and are maintained under required conditions.
- 25 D. Offsite storage agreements will not relieve contractor from using proper storage
26 techniques.

27 1.14 MATERIALS AND EQUIPMENT INSTALLATION

- 28 A. Materials and equipment shall be new and of the make, type, size and quality
29 specified. See Instructions for Bidders for bidding procedure.
- 30 B. Erect equipment in neat workmanlike manner, align, level and adjust for
31 satisfactory operation; install for easy maintenance, inspection, operation, and
32 replacement. Minor deviation from indicated arrangements may be made as
33 approved.

- C. Mechanical equipment shall operate without objectionable noise or vibration. Ductwork and piping shall be provided with flexible couplings to prevent noises or vibration transmission.

1.15 EXISTING EQUIPMENT

- A. The Mechanical Contractor shall remove and or modify existing ductwork and piping as indicated on the construction documents.
- B. The Mechanical Contractor shall remove or modify existing mechanical equipment as indicated on the construction documents.
- C. All equipment removed by the Mechanical Contractor and not reused as part of this project shall, or as requested to be retained by the Owner, become property of the Mechanical Contractor and shall be removed from the premises. Items requested to be retained by the Owner shall be delivered to a site as directed by the Owner.

1.16 DEMOLITION

- A. Perform all demolition as indicated on the drawings to accomplish new work. In occupied areas where demolition work is to be performed adjacent to existing work that remains, construct temporary dust partition to minimize the amount of contamination of the occupied space. Where pipe or ductwork is removed and not reconnected with new work, cap ends of existing services as if they were new work. Coordinate work with building occupant to minimize disruption.
- B. All piping, wiring and associated conduit, insulation, ductwork and similar items demolished, abandoned, or deactivated are to be removed from the site by the Mechanical Contractor unless requested to be retained by the Owner. Maintain the condition of material and/or equipment that is indicated to be reused equal or better to that existing before work began.

1.17 SLEEVES, AND OPENINGS

- A. Pipe Sleeves:
1. Provide galvanized sheet metal sleeves for pipe penetrations through interior walls to provide a backing for sealant or firestopping.
 2. Provide schedule 40 steel pipe for pipe penetrations through exterior walls, non-rated beams, footings and potentially wet applications to provide backing for sealant and firestopping.
 3. Sleeves for piping in new poured concrete construction shall be schedule 40 steel pipe, cast in place.
 4. In all piping floor penetrations, fire rated and non-fire rated, top of sleeve shall extend 1" above the adjacent floor. Caulk sleeves full depth and provide floor plate.
 - a. Sleeves in non-rated floor penetrations shall be 18 gauge galvanized steel.

- b. Sleeves in rated floor penetrations shall be UL listed prefabricated sleeve including seals.
- c. If the pipe penetrating the sleeve is supported by a pipe clamp resting on the sleeve, weld a collar or struts to the sleeve to transfer weight to floor structure.
- 5. In finished spaces where pipe penetration through wall is exposed, provide chrome plated steel escutcheons installed flush with face of penetrated surface.
- 6. Size sleeves large enough to allow for expansion and contraction. Provide for continuous insulation wrapping.

B. Duct Sleeves:

- 1. Duct sleeves are not required in non-rated floors or partitions.
- 2. Provide sleeve required for fire dampers in fire-rated partitions and floors. Install sleeve per manufacturer's recommendation.

C. Openings:

- 1. Any opening over 12" in width penetrating masonry or concrete construction requires additional structural support. Mechanical contractor shall be responsible for coordinating with the General Contractor for sizes and locations of openings.

D. Furnish sleeves to General Contractor for placement into formwork

1.18 FLASHING

- A. Provide flexible flashing and metal counterflashing where piping and ductwork penetrate weather or waterproofed walls, floors and roofs.
- B. Flash pipes projecting 3" minimum above finished roof surface with lead worked one inch minimum into hub, 8" minimum clear on sides with 24x24 sheet size. For pipes through outside walls, turn back into wall and caulk, metal counterflash and seal.
- C. Provide welded curbs for mechanical roof installation 12" minimum high above roofing surface. Flexible sheet flash and counterflash with sheetmetal; seal watertight.
- D. Metal Flashing: 26 gauge galvanized steel.
- E. Lead Flashing: 5 lbs./sq. ft. sheet lead for waterproofing; one lb./sq. ft (5 kg/sq. m) sheet lead for soundproofing.
- F. Flexible Flashing: 47 mil thick sheet butyl; compatible with roofing.
- G. Caps: Steel, 22 gauge minimum; 16 gauge at fire resistant elements.

1.19 CUTTING AND PATCHING, HOLES AND SLEEVES

- 1 A. It shall be the responsibility of the Mechanical Contractor to furnish the
2 applicable contractor with all opening dimensions where required for installing
3 the mechanical work. All dimensions must be verified with equipment shop
4 drawings.
- 5 B. All required core drilling of holes in floors or walls necessary to install piping and
6 conduit is the responsibility of the Mechanical Contractor. All core drilled holes
7 must be drilled carefully as to avoid spalling, and unnecessary damage or
8 weakening of structural members. Avoid chopping or breaking out.

9 1.20 EQUIPMENT ACCESS

- 10 A. Install all piping, conduit, ductwork, and accessories to permit access to
11 equipment for maintenance and service.

12 1.21 GENERAL PRESSURE PIPING SPECIFICATION

- 13 A. The following piping practice shall be followed in installing all steel or copper
14 piping:
- 15 1. Full length of pipe shall be used wherever possible; short lengths of pipe
16 with couplings will not be permitted.
 - 17 2. All pipes shall be cut to exact measurements and shall be installed without
18 forcing or springing so as not to cause excess stress in valves or
19 equipment.
 - 20 3. All piping shall slope a minimum of 1" in 50'-0" in the direction of flow
21 unless otherwise noted on drawings.
 - 22 4. All branch connections shall be made into top of mains unless otherwise
23 noted on drawings.
 - 24 5. All changes in direction shall be made by using pipe and fittings or by
25 shop fabricated pipe bends. Field pipe bends are prohibited.
 - 26 6. Unions shall be installed in all pipe connections to equipment, control
27 valves, controllers, steam traps, and wherever necessary to facilitate the
28 dismantling of piping and removal of other items requiring maintenance.
 - 29 7. Exposed piping shall be neatly arranged, straight, run parallel, and at right
30 angles to walls and shall be so graded that the entire system can be
31 drained. Drain valves shall be installed at low points of piping.
 - 32 8. Install pipe anchors and expansion bends or swing connections where so
33 indicated on drawings.
 - 34 9. Installed piping shall not interfere with the operation or accessibility of
35 doors or windows, shall not encroach on aisle passageways and
36 equipment, and shall not interfere with the servicing or maintenance of
37 any equipment.
 - 38 10. When pipe size is reduced, reducing fittings are required. No bushings
39 shall be used.

40 1.22 PAINTING

1 A. Structural iron HVAC equipment supports and piping exposed to the outdoors
2 shall be given one coat of Rustoleum or equivalent rust-free type paint.
3 Galvanized supports are not paint required.

4 B. See section 23 05 03 – Pipe and Fittings

5 1.23 CLEANING & FLUSHING

6 A. After satisfactory completion of pressure tests, before permanently connecting
7 equipment, traps, strainers, and the like, clean equipment thoroughly, blow and
8 flush piping for a sufficient length of time as directed, so that interiors will be free
9 of foreign matter.

10 B. Cleaning, Heating and Chilled Water Piping Systems:

- 11 1. Use Betz Dearborn pre-operational cleaner Ferroquest FQ7103, Mogul,
12 Vulcan or Nalco in the amount recommended by the manufacturer to pre-
13 clean the piping system. Follow the manufacturer's instructions for
14 treatment and feeding.
- 15 2. Provide 2-gallon shot feeder with shut-off control and drain valves.
- 16 3. Circulate the solution in the system with all automatic valves fully open.
17 Drain the entire system after 24 hours. Fill system with clear water, and
18 circulate for a period of 24 hours while continuously draining and filling
19 the system.
- 20 4. Obtain system water analysis one week later and recommendations for
21 treatment and treat water in accordance with these recommendations.

22 C. Operate other pipe systems for same cleaning period. After cleaning operation,
23 drain all systems, remove start-up strainer screens and install permanent screens;
24 replace packing in expansion joints.

25 D. After all tests are made and the installed work found satisfactory, go over work to
26 clean all equipment, piping, conduit and leave all in a clean and complete working
27 condition. Remove from site all debris that accumulate during installation of the
28 work.

29 E. All equipment specified with factory applied finish shall be wiped clean. If
30 painted surface is scuffed or marred, touch up with paint approved for this
31 service.

32 F. If larger areas are in need of repainting, pay cost for Painting Contractor to
33 refinish the entire surface.

34 1.24 OPERATING TEST

35 A. General:

- 36 1. Perform tests as outlined below and submit test results to the Architect
37 before Owner operates equipment.

2. Equipment shall be complete with all components connected before making tests.
3. Make adjustments, repairs, and alterations, as required to meet specified test results. Correct defects disclosed by tests or inspection; replace defective parts when directed.
4. In replacing defective parts use only new materials; in case of pipe, replace with same length as defective piece.
5. Caulking of screwed joints or peening of welds, will not be permitted.
6. Repeat tests after defects have been corrected and parts replaced, as directed, until pronounced satisfactory.
7. Tests all alarms, flow switches, level controls, low and high-pressure cut outs and all other safety devices. Test results submittal shall list items tested.
8. Bear costs of repairs and restoration of work of other trades damaged by the tests or cutting that had to be done in connection with the tests.

B. Heating System:

1. Adjust and regulate heating system to circulate freely, noiselessly, and to distribute heating media proportionately to all heating surfaces. Adjust and balance hot water heating system to equalize circulation for all heating surfaces. Adjust automatic temperature controls for satisfactory operation.
2. Operate system for tests during heating season of the first year of operation at times when directed, for proper setting and adjusting. Furnish copies of test data as directed.

C. Testing and Balancing:

1. Provide the services of a qualified independent firm engaged in the business of air balance to adjust and balance ventilating systems.

D. Refrigeration:

1. Test refrigeration equipment under 100% load conditions, artificial if necessary, before Owner operates equipment.

1.25 OPERATION AND MAINTENANCE MANUALS

- A. Maintenance manuals shall be prepared covering the HVAC systems of the building, including refrigeration and temperature controls.
- B. Submit manuals in the quantity and format as specified in Division 01 section Contract Closeout.
- C. These manuals shall include the following information:
 1. Name and address and telephone number of installing General Contractor and Subcontractors
 2. Description of Systems
 3. Test results and reports
 - a. Installation checks on pumps, fans and related equipment

- b. Air balance
- c. Results of all pressure tests with witness signature, data made, etc.
- d. Water treatment test results, including tests for absence of bacteria in domestic water system
- e. Valve identification charts
4. General Operating Instructions: Instructions shall include locations of equipment or controls, which will require periodic adjustment.
5. Maintenance Instruction: These shall include manufacturer's maintenance for all equipment.

D. The above information including equipment shop drawings, fixture cuts, etc. shall be placed in three ring loose-leaf hard cover binders with section tabs labeled with project name and contents. Submit to Architect prior to final billing.

1.26 RECORD DRAWINGS

- A. Prepare and submit to Architect/Engineer a complete layout of piping and duct systems as actually installed showing location, size changes, and elevations for permanent record drawings. Drawings must be provided in AutoCad .dwg format for reproduction along with (1) hard copy.

1.27 IDENTIFICATION

A. General:

1. Do not label equipment such as cabinet heaters, convectors, radiation, ceiling fans or any other equipment in occupied spaces.

B. Pipe:

1. All piping shall be color-coded using legend markers and directional arrows after piping has been covered (if specifications call for insulation) and after piping has been painted.
2. Use Setmark System pipe markers with arrows as manufactured by Seton Name Plate Corp. Pipe stencils are not acceptable.
3. Install markers as recommended by the manufacturer.
4. Locate pipe identification as follows:
 - a. Within 1'-6" of each valve
 - b. Within 3'-0" of each 90° elbow
 - c. Within 3'-0" of piping connection to equipment
 - d. Within 3'-0" of where pipe enters shafts and penetrates floor and outside walls.
 - e. Maximum 20'-0" intervals along all piping (exposed and concealed). Not less than one label shall be installed per room.
 - f. Within 1'-6" of any access door or panel
 - g. At all tees within 3'-0" of both mains and branch piping.
 - h. Where new piping meets existing piping, place one additional label on existing piping as specified in items 'a' through 'f'.

- i. On remodeling projects, contractor shall include in bid, one extra (case or roll) of all ordered system colors and/or bands to turn over to owner.
- j. Stenciling of piping is not acceptable.

C. Valves:

- 1. After piping work is complete and pipe insulation is finished, tag valves on all piping. Valve tags are not required at a terminal device unless the valves are greater than ten feet from the device or located in another room not visible from the terminal unit. Identify valves with consecutive numbers on tags.
- 2. Provide Seton Name Plate Company Style M4506 brass valve tags, 1-1/2" diameter, black filled characters, 1/2" numbers, 1/4" letters, with size No. 6 nickel-plated bead chains for fastening to each valve stem as required.
- 3. Abbreviations are as follows:
 - a. Ventilating VNTG
 - b. Plumbing PLBG
 - c. Heating HTG
 - d. Refrigeration REF
- 4. Furnish Seton Name Plate Company 37411 valve identification charts in a satin-finish self-closing aluminum frame, size 9-1/2" x 12".
- 5. Complete chart showing contractor's name and address, name of system, number, location, and purpose of each valve tagged.
- 6. Mount enclosed chart in Mechanical Room or Boiler Room or as directed by the owner.
- 7. Provide two (2) copies of charts and place in Maintenance Manual.

D. Exterior Mounted Equipment:

- 1. Identify exterior mounted mechanical equipment by stenciling equipment number with black enamel against a light background or white enamel against a dark background. Use a primer where necessary for proper paint adhesion.
- 2. Whenever possible, paint equipment number so it is visible from point of roof access.

E. Interior mounted equipment:

- 1. Provide Seton Seatonflex Style M1771 Name Plate for all equipment such as air handling equipment, pumps, package air conditioners and starters. Plates shall bear name of equipment as noted in drawings and specifications i.e., Supply Fan #1. Plates shall be 2-1/2" x 3/4" multi-layered acrylic, white characters with a black background.

F. Submit a list of plates for Architect's approval before ordering.

1.28 TESTING, ADJUSTING AND BALANCING

A. See requirements in Section 23 05 93 – Testing, Adjusting, and Balancing

- 1 B. Include the complete cost of air and hydronic system testing and balancing in the
2 Bid.
- 3 C. T & B procedures, methods and instrumentation shall be in strict accordance with
4 the established standards of the National Environmental Balancing Bureau
5 (NEBB) or the Associated Air Balance Council (AABC).
- 6 D. Provide the services of a qualified independent NEBB or AABC certified firm
7 engaged in the business of air balance to adjust and balance ventilating systems.
- 8 E. Mechanical Contractor shall assume the responsibility for the following:
9 1. Purchase and installation of any replacement component of equipment
10 drive assemblies as directed by the Test and Balance Contractor.
11 2. Filter replacement and installation.
12 3. Adjustment of isolation devices.
13 4. Equipment conformity to sound level requirements.
14 5. Purchase and replacement of motor starter heater elements, as directed.
15 6. Removal, cleaning or replacement of hydronic system strainers.
16 7. Draining, filling and venting of hydronic systems.
17 8. Proper adjustment and calibration of temperature control instruments and
18 devices.
19 9. Water treatment if specified, system cleaning and general equipment
20 housekeeping.
21 10. Leak testing of ductwork and piping.
22 11. Installation of volume dampers where shown, or where required as
23 directed by the Test and Balance Contractor.
24 12. Instruction to owner on system operation.
25 13. Furnishing of ladders and or scaffolding as directed by the Test and
26 Balance Contractor.
27 14. Furnish the Test and Balance Contractor with one set of "As-built"
28 drawings and one complete set of certified shop drawings at least two
29 weeks prior to commencement of work.

30 1.29 HVAC SYSTEM COMMISSIONING

- 31 A. Submit an HVAC Building Commissioning Certification, which states that the
32 Heating, Ventilating and Air Conditioning System has been installed according to
33 and is in compliance with the intent of the design parameters of the Division 23
34 HVAC Specification.
- 35 B. This Commissioning Certification shall include, but not be limited to, adjusting
36 air quantities and control of air handling units, VAV box dual minimum settings,
37 fan interlocks, damper positions, boiler sequencing, pump and fan operation.
- 38 C. Submit the HVAC Commissioning Certification to the Architect prior to the final
39 payment request.

40 END OF SECTION

SECTION 23 05 03

PIPING AND FITTINGS

PART 1 GENERAL

1.01 SCOPE

- A. All work in this section is subject to the provisions of the General HVAC Requirements, and all other parts of the Contract Documents applicable to this Section of Work.

1.02 WORK INCLUDED

- A. Refrigerant Piping
- B. Unions and Flanges

1.03 RELATED WORK

- A. Section 23 05 29 - Supports and Anchors
- B. Section 23 07 01 - HVAC Piping Insulation

1.04 REFERENCES

- A. ANSI/ASME - Boiler and Pressure Vessel Code
- B. ANSI/ASME Sec 9 - Welding and Brazing Qualifications
- C. ANSI/ASME B16.23 - Cast Copper Alloy Solder Joint Drainage Fittings - DWV
- D. ANSI/ASME B16.29 - Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings - DWV
- E. ANSI B31.1 - Code for power piping (over 125 psig)
- F. ANSI/ASME B31.9 - Building Services Piping
- G. ANSI/AWS A5.8 - Brazing Filler Metal
- H. ANSI Z49.1 - Safety in Welding and Cutting
- I. ASTM A53 - Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless
- J. ASTM A120 - Pipe, Steel, Black and Hot-Dipped Zinc Coated (Galvanized), Welded and Seamless, for Ordinary Uses

1 K. ASTM A234 - Pipe Fittings of Wrought Carbon Steel and Alloy Steel for
2 Moderate and Elevated Temperatures

3 L. ASTM B32 - Solder Metal

4 M. ASTM B88 - Seamless Copper Water Tube

5 N. AWS D1.1 - Structural Welding Code

6 1.05 SUBMITTALS

7 A. Submit product data under provisions of Section 23 05 00.

8 B. Include data on pipe materials, pipe fittings, and accessories.

9 PART 2 PRODUCTS

10 2.01 REFRIGERANT PIPING

11 A. ASTM B88, type L, hard drawn copper tube, cleaned and capped in accordance
12 with ASTM B280, and marked "ACR", with ANSI B16.22 wrought copper or
13 forged brass solder type fittings.

14 B. Pre-charged tubing with manufacturer's standard refrigerant specialties maybe
15 used on systems less than 5-tons.

16 2.02 UNIONS AND FLANGES

17 A. 2" and smaller: ASTM A197/ANSI B16.3 malleable iron unions with brass seats.
18 Use black iron on black steel piping. Use unions of a pressure class equal or
19 higher than that specified for the fittings of the respective piping service but not
20 less than 250 psi.

21 B. 2 1/2" and larger: ASTM 181 or A105, grade 1 hot forged steel flanges of
22 threaded, welding neck, or slip-on pattern and of a pressure class compatible with
23 that specified for valves, piping specialties and fittings of the respective piping
24 service. Flanges smaller than 2 1/2" may be used as needed for connecting to
25 equipment and piping specialties. Use raised face flanges ANSI B16.5 for mating
26 with other raised face flanges on equipment with flat ring or full face gaskets.
27 Use ANSI B16.1 flat face flanges with full face gaskets for mating with other flat
28 face flanges on equipment. Gasket material to be non-asbestos and suitable for
29 pressures and temperatures of the piping system.

30 PART 3 EXECUTION

31 3.01 PREPARATION

32 A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

- B. Remove scale and dirt on inside and outside before assembly.
- C. Prepare piping connections to equipment with flanges or unions.
- D. After completion, fill, clean, and treat systems.

3.02 INSTALLATION

A. General:

1. Install all piping plumb and parallel to building walls and ceilings and at heights which do not obstruct any portion of windows, doorways, stairways, or passage ways. Where interferences develop in the field, offset or reroute piping as required to clear such interferences
2. Group piping whenever practical at common elevations.
3. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
4. Provide clearance for installation of insulation, and access to valves and fittings.
5. Do not route piping through transformer vaults, or above transformers, panel boards, or switchboards including the required service space for this equipment, unless the piping is serving this equipment.
6. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors.
7. Install unions downstream of valves and at equipment or apparatus connections.
8. Welding is required on all black piping 2 1/2" and larger.
9. Copper piping may be used for heating water service in lieu of Schedule 40 Black on piping 2" and smaller. Install brass ball valve at junction of dissimilar piping.

B. Welded Pipe Joints:

1. Make all welded joints by fusion welding in accordance with ASME Codes, ANSI B31, and State Codes where applicable.

C. Threaded Pipe Joints:

1. Use a thread lubricant or Teflon tape on threaded pipe joints; no hard setting pipe thread cements or caulking is allowed.

PART 4 REFRIGERANT

A. Refrigerant:

1. Refrigerant piping to be installed by firms who are experienced in installation of such piping and in accordance with the requirements of Wisconsin Administrative Code Section ILHR 45.

2. All solder joints to be ASTM Grade 4 or 5 and have a melting point of approximately 1250 degrees F. Solder impurities shall not exceed 0.15%. Tubing to be new and delivered to job site with the original mill end caps in place. Clean and polish all joints before soldering. Purge all lines with nitrogen during soldering. Provide manual shut-off and check valves as required.
3. No refrigerant is to be vented directly to the atmosphere. During evacuation procedures, use equipment designed to recover and allow recycling of refrigerant.
4. After completion of leak tests, evacuate system with a vacuum pump to an absolute pressure not to exceed 1500 microns while the system ambient temperature is above 60 deg. F. Break the vacuum to 2 psig with the refrigerant to be used in the system. Repeat the evacuation procedure. Install a drier of the required size in the liquid line, open the compressor suction and discharge valves, and evacuate to an absolute pressure not to exceed 500 microns. Leave vacuum pump running for not less than two hours without interruption. Raise system pressure to 2 psig with refrigerant and remove vacuum pump.
5. Charge refrigerant directly from original drums through a combination filter-drier. Charge the system by means of a charging fitting in the liquid line. Record the weight of the refrigerant in the system.

B. Unions and Flanges:

1. Install unions and flanges as required at each automatic control valve and at each piping specialty or piece of equipment which may require removal for maintenance, repair, or replacement. Where a valve is located at a piece of equipment, locate the flange or union connection on the equipment side of the valve.

C. Leak Testing:

1. Verify that the piping system being tested is fully connected to all components and that all equipment is properly installed, wired and ready for operation. If required for additional pressure load under test, provide temporary restraints at expansion joints or isolate them during test.
2. Do not insulate piping systems until system has been properly tested and repaired. If leaks are found, repair area with new materials and repeat test. Caulking of leaks is not acceptable.
3. Refrigerant: Leak test system by charging the system to pressure of 10 psig with an HFC refrigerant. Test with the compressor suction and discharge valves closed and with all other system valves open. Increase pressure to 300 psig with dry nitrogen. Check for leaks with an electric leak detector having a certified sensitivity of at least one ounce per year. Seal any leaks found and retest system.

END OF SECTION

SECTION 23 05 13

MOTOR AND STARTERS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and General Provisions of the contract, including General and Supplementary Conditions and Division 01 specification sections apply to work of this Section.

1.02 RELATED WORK

1.03 APPLICABLE PUBLICATIONS

- A. Conform to requirements of current ANSI/NFPA 70 - National Electric Code.
- B. Conform to current National Electrical Manufacturers Association (NEMA) Standards.
- C. Conform to current Underwriters Laboratories (UL) Specifications and Standards.
- D. Conform to National Electrical Contractors Association (NECA) "Standards of Installation".
- E. Constructed in accordance with ASME
- F. Conform to Electrical Equipment Manufacturers Advisory Council Standards
- G. Device specific standards are included in product specifications.

1.04 DESCRIPTION OF WORK

A. MECHANICAL CONTRACTOR

- 1. Shall furnish all starting equipment including selector switches, relays, etc. He shall turn all manual and magnetic starters over to the Electrical Contractor with complete instructions and wiring diagrams required for a complete installation. All other control equipment shall be turned over to the Temperature Control subcontractor for installation.
- 2. Verify final locations with the Owner and the Electrical Contractor.
- 3. Shall furnish and install all control wiring.
- 4. Shall confirm voltage requirements with the Electrical Contractor prior to ordering equipment.

B. ELECTRICAL CONTRACTOR

1. Will install all fused and/or circuit breaker disconnect switches that are furnished with mechanical equipment or by the Mechanical Contractor. Electrical Contractor shall coordinate exact requirements with the Mechanical Contractor and the actual equipment furnished.
2. Will furnish and install all power wiring from panel board to motors and junction boxes in factory-assembled units.
3. Will install all starters in cooperation with and under the supervision of the Mechanical Contractor.

1.05 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Section 23 05 00.
- B. Include dimensions, capacities, materials of construction, weights, wiring diagrams and appropriate identification for all equipment in this Section.
- C. Submit manufacturer's installation instructions.

1.06 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Section 23 05 00.

1.07 REFERENCE STANDARDS

- A. ANSI/IEEE 112 – Test Procedure for Polyphase Induction Motors and Generators
- B. Constructed in accordance with ASME
- C. ANSI/NEMA MG-1 – Motors and Generators
- D. ANSI/NFPA 70 – National Electrical Code
- E. IECC 2015 with Wisconsin amendments (SPS 363)

PART 2 PRODUCTS

2.01 MOTOR REQUIREMENTS

- A. All electric motors shall be NEMA standard motors.
- B. All electronically commutated (EC) motors shall be complete with integral potentiometer, motor power input wire whip, and motor control input wire whip for 0-10 VDC control signal.
- C. All motors 1 HP and larger shall meet or exceed requirements of ASHRAE 90.1.

1 D. All motors 1-1/2 HP and larger shall meet or exceed local utility requirements
2 for high efficiency motors. Mechanical Contractor shall verify current
3 requirements with utility.

4 E. All motors used on variable frequency drives must be suitable for use with the
5 drive, including but

6 2.02 STARTING EQUIPMENT

7 A. Manufacturers: Allen-Bradley, Cutler Hammer, Eaton, Johnson Controls, Square
8 D, General Electric, Franklin Control Systems, Taco, or ABB Control Inc.

9 B. All starters shall be NEMA standard sizes and all starting equipment shall be of
10 the same manufacturer.

11 C. All starters, push buttons and selector switches shall have NEMA Type 1
12 enclosures.

13 2.03 SINGLE PHASE, MANUAL STARTER

14 A. All manual starters shall be two pole for single phase fractional horsepower
15 service with lockable on-off switch, hand-off-auto, power-run-fault indication
16 lights, electronic overload protection, control system contacts, auxiliary dry
17 contacts, manual-auto reset selection, fault relay, status relay, and power failure
18 return mode. Franklin BAS-1P, Johnson Controls BMMS-1P, Taco T1P, or
19 approved equal.

20 B. Except where indicated otherwise, all magnetic starters shall be combination type
21 with circuit breaker across the line for three phase service with reset button in
22 cover, pilot light, overload protection for each phase, undervoltage protection,
23 missing phase protection, phase reversal, built- in control circuit transformer with
24 120 volt operating coils and hand-off-auto selector switch factory mounted in
25 starter flange.

26 C. All starters shall be equipped with auxiliary contacts or control relays for
27 equipment control interlocking as required.

- 28 1. Snap action switch.
- 29 2. Thermal overload device.
- 30 3. Locking attachment.
- 31 4. Pilot indicating light.
- 32 5. Conform to NEMA ICS2 and EEMAC standards.

33 D. Enclosure

- 34 1. NEMA type 1, NEMA type 4X as required.

35 PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that equipment is in compliance with approved submittal drawings.
- B. Examine area to receive motor starter to assure adequate clearance for motor starter installation.
- C. Start work only after unsatisfactory conditions have been corrected.

3.02 FIELD MEASUREMENTS

- A. Field verify locations of panelboards with other trades. Adjust as required to meet field conditions and code requirements.

3.03 DELIVERY, STORAGE AND HANDLING

- A. Receive, sign for and store all equipment in this section.
- B. Maintain original quality and condition of equipment while it is in storage.
- C. Do not store motor starters exposed to weather.
- D. Protect motor starters against damage from work of other trades.

3.04 INSTALLATION

A. General:

- 1. The complete installation shall be done in a neat, workmanlike manner in accordance with all applicable codes and the manufacturer's recommendations.
- 2. Install all fixtures, materials, assemblies and equipment in strict accordance with manufacturer's recommendations and instructions. Consult manufacturer for all wiring diagrams, schematics, sizes, outlets, etc. before installing.
- 3. Start of installation shall not begin until detention areas are broom clean, properly lighted, exterior enclosing walls in place, exterior windows glazed, roof completely installed to prevent weather damage to equipment, and written notice received by ESC from Architect stating that these conditions exist at building site.
- 4. The electrical installation shall conform to division 26 specification.

B. Grounding

- 1. All equipment shall be grounded in accordance with NEC, these specifications and drawings, and the equipment supplier's recommendations.
- 2. Install mounted firmly to wall of structural surface.

1 C. Final Testing

- 2 1. Verify over current protection thermal unit size with motor nameplate to
3 provide proper operation and compliance with NEC.
4 2. Megger check of phase-to-phase and phase-to-ground insulation levels.
5 3. Do not megger check solid state equipment.
6 4. Test for continuity between line and load terminals and between control
7 terminals.
8 5. Short circuit.
9 6. Operational check.
10 7. Test each motor and permanently record following information:
11 a. Motor identification as to the load served.
12 b. Nameplate data.
13 c. Overload relay equipment.
14 d. Protective relay (if any) setting.
15 e. Voltage and current phase readings.
16 f. Direction of rotation.
17 g. Furnish spare overloads in each size utilized and turn over to
18 owner.

19 D. Adjustment And Cleaning

- 20 1. Adjust covers and operating mechanisms for free mechanical movement.
21 2. Tighten wire and cable connections.
22 3. Clean interior of enclosure.
23 4. Touch up scratched or marred surfaces to match original finish.

24 END OF SECTION

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SECTION 23 05 29

SUPPORTS AND ANCHORS

PART 1 GENERAL

1.01 SCOPE

- A. All work in this section is subject to the provisions of the General HVAC Requirements, and all other parts of the Contract Documents applicable to this Section of Work.

1.02 WORK INCLUDED

- A. Pipe, duct, and equipment hangers, supports, and associated anchors
- B. Equipment bases and supports

1.03 WORK FURNISHED BUT INSTALLED UNDER OTHER SECTIONS

- A. Furnish hanger and support inserts to General Contractor for placement into formwork.

1.04 RELATED WORK

- A. Section 23 05 03 – Piping and Fittings
- B. Section 23 07 01 – HVAC Piping Insulation

1.05 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Section 23 05 00.
- B. Indicate hanger and support framing and attachment methods.

PART 2 PRODUCTS

2.01 PIPE HANGERS AND SUPPORTS

- A. Manufacturers:
 - 1. Grinnell
 - 2. B-Line
 - 3. Mason
 - 4. Michigan Hanger
 - 5. Unistrut
- B. Hangers for Pipe Sizes 1/2" to 1-1/2": Carbon steel, adjustable swivel, split ring.

- C. Hangers for Pipe Sizes 2" to 4" and Cold Pipe Sizes 5" and Over: Carbon steel, adjustable, clevis.
- D. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods; cast iron roll and stand for hot pipe sizes 5" and over.
- E. Wall Support for Pipe Sizes to 3" (76 mm): Cast iron hook.
- F. Wall Support for Pipe Sizes 4" and Over: Welded steel bracket and wrought steel clamp.
- G. Vertical Support: Steel riser clamp.
- H. Floor Support for Pipe Sizes to 4" and All Cold Pipe Sizes: Cast iron adjustable pipe saddle, locknut nipple, floor flange, and concrete pier or steel support.
- I. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
- J. Shield for Insulated Piping 2" and Smaller: 18 gauge galvanized steel shield over insulation in 180 degree segments, minimum 12" (300 mm) long at pipe support.
- K. Shield for Insulated Piping 2-1/2" and Larger (Except Cold Water Piping): Pipe covering protective saddles.
- L. Shields for Insulated Cold Water Piping 2-1/2" and Larger: Hard block non-conducting saddles in 90 degree segments, 12" minimum length, and block thickness same as insulation thickness.
- M. Shields for Vertical Copper Pipe Risers: Sheet lead.

2.02 HANGER RODS

- A. Steel Hanger Rods: Threaded both ends, threaded one end, or continuous threaded.
- B. Size rods for individual hangers and trapeze support as indicated below:

<u>Max. Load (Lbs.)</u>	<u>Rod Diameter</u>
610	3 / 8"
1130	1 / 2"
1810	5 / 8"
2710	3 / 4"
3770	7 / 8"
4960	1"
8000	1-1 / 4"

- C. Total weight of equipment, including valves, fittings, pipe, pipe content and insulation are not to exceed the limits indicated. Provide rods complete with adjusting and lock nuts.

2.03 BEAM CLAMPS

- A. Malleable black iron clamp for attachment to beam flange to 0.62" thick with a retaining ring and threaded rod of 3/8", 1/2", and 5/8" diameter. Furnish with a hardened steel cup point set screw.

2.04 INSERTS

- A. Inserts: Malleable iron case of steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.05 ANCHORS

- A. Use welding steel shapes, plates and bars to secure piping to structure.

2.06 FABRICATION

- A. Design hangers without disengagement of supported pipe.
B. Provide copper plated hangers and supports for copper piping.

2.07 FINISH

- A. Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

2.08 CONCRETE EQUIPMENT PADS

- A. Furnished and installed by Mechanical Contractor. Dimensions to be based on approved shop drawings.

2.09 EQUIPMENT STANDS

- A. Use contractor fabricated stand consisting of structural steel members supported by pipe supports. All steel exposed to the weather to be galvanized, painted or stainless steel.

2.10 EQUIPMENT CURBS, EQUIPMENT RAILS AND PIPE CURB ASSEMBLIES

- A. Manufacturers:
1. Pate
2. Roof Products
3. ThyCurb

- 1 4. Vent Products
2 5. Custom Curb
3 6. Equipment manufacturer's curbs constructed to match their equipment is
4 acceptable if curb is approved by the National Roofing Contractors
5 Association.

- 6 B. Pipe curb assemblies shall be constructed of not less than 18 gauge galvanized
7 steel reinforced so it is structurally capable of supporting the intended load, inside
8 and outside corner sections that are mitered and continuously welded, lined with a
9 minimum 1 1/2" thick, 3 lb. density insulation, integral deck mounting flange,
10 nominal 2" thick wood nailer, laminated acrylic clad thermoplastic cover with
11 graduated step boots to accommodate size and quantity of pipes, fasten screws for
12 cover, and stainless steel clamps for securing boots around piping. Curb heights
13 shall be as indicated on drawings. Top of roof curbs shall be level, with pitch
14 built into curb when deck slopes 1/4" of an inch per foot or greater.

15 PART 3 EXECUTION

16 3.01 INSERTS

- 17 A. Provide inserts to General Contractor for placement in concrete formwork.
18 B. Provide inserts for suspending hangers from reinforced concrete slabs and sides of
19 reinforced concrete beams.
20 C. Provide hooked rod to concrete reinforcement section for inserts carrying pipe
21 over 4".

22 3.02 PIPE HANGERS SUPPORTS, AND ANCHORS:

- 23 A. Support horizontal piping as follows:

25 PIPE SIZE	MAX. HANGER SPACING	HANGER DIAMETER
26 1/2" to 1-1/4"	6'-6"	3/8"
27 1-1/2" to 2"	10'-0"	3/8"

- 28 B. Install hangers to provide minimum 1/2" space between finished covering and
29 adjacent work.
30 C. Use hangers with 1-1/2" minimum vertical adjustment.
31 D. Support vertical piping with clamps secured to the piping and resting on the
32 building structure at each floor. Piping 5" or greater, of lengths exceeding 30
33 feet, shall be additionally supported on base elbows secured to the building
34 structure, with flexible supporting hangers provided at the top of riser to allow for
35 expansion and contraction.

- 1 E. Where several pipes can be installed in parallel and at same elevation, provide
2 multiple or trapeze hangers.
- 3 F. Support riser piping independently of connected horizontal piping.
- 4 G. Do not hang piping directly from a metal deck or run piping so it rests on the
5 bottom cord of any truss or joist.
- 6 H. Install hangers and supports to provide for free expansion of the pipe system.
7 Support all piping from the structure using concrete inserts, beam clamps, ceiling
8 plates, wall brackets or floor stands. Fasten ceiling plates and wall brackets
9 securely to the structure.
- 10 I. Install anchors where indicated on drawings. Where not specifically indicated,
11 install anchors at ends of principal pipe runs and at intermediate points in pipe
12 runs between expansion loops.

13 3.03 EQUIPMENT BASES AND SUPPORTS

- 14 A. Provide templates, anchor bolts, and accessories for mounting and anchoring
15 equipment.
- 16 B. Construct support of steel members. Brace and fasten with flanges bolted to
17 structure.
- 18 C. Provide rigid anchors for pipes after vibration isolation components are installed.

19 END OF SECTION

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SECTION 23 05 93

TESTING, ADJUSTING AND BALANCING

PART 1 GENERAL

1.01 SCOPE

- A. All work in this section is subject to the provisions of the General HVAC Requirements, and all other parts of the Contract Documents applicable to this Section of Work.

1.02 WORK INCLUDED

- A. Testing, adjusting and balancing of air and water side of heating, ventilating and air conditioning systems.

1.03 REFERENCE STANDARDS

- A. Wisconsin Administrative Code – Chapter Comm 64.53
- B. AABC – National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems
- C. NEBB – Procedural Standards for Testing, Adjusting and Balancing or Environmental Systems
- D. ASHRAE Handbook, 1999 HVAC Applications, Chapter 36, Testing, Adjusting and Balancing

1.04 DESCRIPTION

- A. Provide total mechanical systems testing, adjusting, and balancing. Requirements include the balance of air and water distribution, adjustment of new and or existing systems to provide design quantities indicated on drawings, electrical measurement and verification of performance of all equipment, all in accordance with standards published by AABC or NEBB and in accordance with Wisconsin Administrative Code – Chapter Comm 64.53.
- B. Test, adjust, and balance all air and hydronic systems so that each room, piece of equipment or terminal device is using quantities indicated on the drawings and in the specifications.
- C. Accomplish testing, adjusting and balancing work in a timely manner with completion of work in the time stated in the Instruction to Bidders and in accordance with the completion schedule established for this project.

1.05 SUBMITTALS

- 1 A. Submit (4) sets of testing, adjusting and balancing reports bearing the seal and
2 signature of the NEBB or AABC Certified Test and Balance Supervisor to
3 Architect's office. The reports to be certified proof that the systems have been
4 tested, adjusted and balanced in accordance with the referenced standards; are an
5 accurate representation of how the systems have been installed and are operating;
6 and are an accurate record of all final quantities measured to establish normal
7 operating values of the systems.
- 8 B. Provide the following information, forms and data:
9 1. General Information: Inside cover sheet identifying Test and Balance
10 Contractor, Mechanical Contractor, and Project Name. Include addresses,
11 contact names and telephone numbers. Also include a certification sheet
12 containing the seal and signature of the Test and Balance Supervisor.
13 2. Provide full air system and hydronic system test results.
14 3. Summary: Provide summary sheet describing mechanical system
15 deficiencies. Describe objectionable noise or drafts found during testing,
16 adjusting and balancing. Provide recommendation for correcting
17 unsatisfactory performances and indicate whether modifications required
18 are within the scope of the contract, are design related or installation
19 related. List instrumentation used during testing, adjusting and balancing
20 procedures.
21 4. Forms: Provide appropriate standard NEBB or AABC forms for each
22 respective item and system. Fill out forms completely. Where
23 information cannot be obtained or is not applicable, indicate same.
- 24 C. Products:
25 1. Provide all required instrumentation to obtain proper measurements.
26 Application of instruments and accuracy of instruments and measurements
27 to be in accordance with the requirements of NEBB or AABC Standards
28 and Instrument manufacturer's specifications.

29 1.06 GENERAL PROCEDURES

- 30 A. Test and Balance contractor shall be responsible for obtaining any applicable
31 construction addendums, construction bulletins, applicable change orders and
32 approved shop drawings pertaining to this work.
- 33 B. Check all filters for cleanliness, dampers and valves for correct positioning,
34 equipment for proper rotation and belt tension, temperature controls for
35 completion of installation and hydronic systems for proper charge and purging of
36 air.
- 37 C. Do not proceed until systems are fully operational with all components necessary
38 for complete testing, adjusting and balancing. Installing contractors are required
39 to provide personnel to check and verify system completion, readiness for
40 balancing and assist Testing and Balancing Contractor in providing specified
41 system performance.

- D. In areas containing ceilings, remove ceiling tile to accomplish testing and balancing work; replace all tile when work is complete and provide new tile to any tile damaged by this procedure.
- E. Cut insulation, ductwork and piping for installation of test probes to the minimum extent necessary for adequate performance of procedures. Patch using materials identical to those removed, maintaining vapor barrier integrity and pressure rating of systems.
- F. Contact the temperature control contractor for assistance in operation and adjustment of controls. Cycle controls and verify operation and set points. Include in report description of temperature control operation and deficiencies found.
- G. Permanently mark equipment settings, including damper and valve positions, control settings, and similar devices allowing settings to be restored. Set and lock all memory stops.
- H. Leave systems in proper working order, replacing belt guards, closing access doors and electric boxes, and restoring temperature controls to normal operating settings.

1.07 TESTING, ADJUSTING AND BALANCING PROCEDURES

- A. Air System Balancing:
 - 1. Identify each mechanical fan system by tag and location.
 - 2. Identify each terminal device by tag and as to location and fan system
 - 3. In air systems employing filters, blank off sufficient filter area to simulate a pressure drop that is midway between that of a clean filter and that of a dirty filter.
 - 4. Measure, adjust and record fan speed to design requirements.
 - 5. Measure and record motor full load amperage and calculated BHP.
 - 6. Measure and record static air pressure conditions across fans, coils and filters.
 - 7. Measure, adjust and record all main supply air ducts, return air ducts and zones to proper design airflows.
 - 8. Measure and record all air temperatures; supply air, return air, mixed air, and outside air including dry and wet bulb temperatures.
 - 9. Adjust outside air, return air and relief air dampers for design conditions at both the minimum and maximum settings and record both sets of data.
 - 10. Balance variable air volume systems at full cooling flow rate, minimum flow rate, and heating flow rate; record all data.
 - 11. Balance all modulating dampers at extreme conditions and record both sets of data.
 - 12. Adjust grilles, diffusers and registers to achieve proper air distribution patterns and uniform space temperatures free from objectionable noise and drafts with the capabilities of the installed system.

- 1 13. Provide fan and motor drive sheave adjustments necessary to obtain
2 design performance. Include in scope of services cost of new sheaves and
3 belts if it becomes necessary to attain design performance.
4 14. Adjust fan drives, dampers, terminals and controls to maintain pressure
5 relationships in areas or rooms designed to maintain positive, negative or
6 neutral air pressures with respect to adjacent spaces, as indicated by the
7 design air quantities.
8 15. The Contractor shall include in the bid the cost of new sheaves and belts if
9 it becomes necessary to change the drives during balancing of system.
10 16. Final air system measurements to be within the following range of
11 specified cfm:
12 a. Fans 0% to +10%
13 b. Supply grilles, registers, diffusers 0% to +5%
14 c. Return/exhaust grilles 0% to -5%
15 d. Room pressurization air -5% to +5%
16 e. NOTE: Airside of system must be balanced completely before
17 starting water balance.

18 1.08 QUALITY ASSURANCE

- 19 A. All work performed under this Section shall be under the direction of the
20 supervisor who is designated and qualified under the certification requirements of
21 NEBB and/or AABC.
22 B. Coordinate system balancing requirements with Section 23 09 93, 23 09 00 and
23 Division 26.

24 END OF SECTION

SECTION 23 07 00

DUCTWORK INSULATION

PART 1 GENERAL

1.01 SCOPE

- A. All work in this section is subject to the provisions of the General HVAC Requirements, and all other parts of the Contract Documents applicable to this Section of Work.

1.02 WORK INCLUDED

- A. Materials
- B. Insulation jackets

1.03 RELATED WORK

- A. Section 23 05 29 – Supports and Anchors
- B. Section 23 31 00 - Ductwork

1.04 REFERENCES

- A. ANSI/ASTM C553 - Mineral Fiber Blanket and Felt Insulation
- B. ANSI/ASTM C612 - Mineral Fiber Block and Board Thermal Insulation
- C. ASTM E84 - Surface Burning Characteristics of Building Materials
- D. NFPA 255 - Surface Burning Characteristics of Building Materials
- E. UL 723 - Surface Burning Characteristics of Building Materials

1.05 QUALITY ASSURANCE

- A. Applicator: Company specializing in ductwork insulation application with three years minimum experience.
- B. Materials: UL listed; flame spread/fuel contributed/smoke developed rating in accordance with NFPA 255, max. flamespread rating of 25, max. smoke developed rating of 50.

1.06 SUBMITTALS

- A. Submit product data under provisions of Section 23 05 00.

1 B. Include product description, list of materials and thickness for each service, and
2 locations.

3 C. Submit manufacturer's installation instructions under provisions of Section 23 05
4 00.

5 PART 2 PRODUCTS

6 2.01 MATERIALS

7 A. Type A: Flexible glass fiber; ANSI/ASTM C553; commercial grade; 1.5 lb./cu.
8 ft. density; 'k' value of 0.24 at 75° F mean temperature, 0.002" foil scrim facing.

9 B. Type B: Rigid glass fiber; ANSI/ASTM C612, Class 1; 3.0 lb./cu. ft. density; 'k'
10 value of 0.23 at 75° F mean temperature, 0.002" foil scrim facing.

11 C. Type C: Rigid glass fiber; ANSI/ASTM C612, Class 1; 'k' value of 0.24 at 75° F
12 and in addition apply heavy brush coat of Benjamin Foster 30-36 Sealfas. Imbed
13 glass cloth and while still wet apply brush coat of Benjamin Foster 30-36 Sealfas
14 over glass cloth.

15 D. Type D: Interior Duct Lining (Low Velocity):
16 1. All ducts calling for thermal and/or acoustical lining shall be lined with
17 flexible glass fiber duct liner with black mat facing with average density
18 1-1/2 lbs., Johns-Manville Lina Caustic or approved equal. Duct liner
19 shall have conductivity not to exceed .26 BTU/in./sq. ft./F./Hr. at mean
20 temperature of 75° F. Liner must have sound absorption coefficient of .68
21 at 500 frequency based on #6 mounting and 1" thickness. Duct sizes on
22 plans are minimum - add for insulation.

23 E. Type E: Rigid Closed Cell Poly-Isocyanurate 2.05 lb./cu. ft. density; 'k' value of
24 0.19 at 75° F mean temperature; 24 lb./sq. in. compressive strength, wrapped with
25 28 gauge aluminum jacket. Seal and caulk all seams with a silicone sealant.

26 F. Adhesives: Waterproof, fire-retardant type.

27 G. Impala Anchors: Galvanized steel, 12 gauge, and self-adhesive pad.

28 H. Joint Tape: Glass fiber cloth, open mesh.

29 I. Tie Wire: Annealed steel, 16 gauge.

30 PART 3 EXECUTION

31 3.01 PREPARATION

32 A. Install materials after ductwork has been tested and approved.

33 B. Clean surfaces for adhesives.

3.02 INSTALLATION

- A. Install materials in strict accordance with manufacturer's instructions.
- NOTE: Contractor shall verify with manufacturer the proper initial 'Heat-Up' method for curing of binders in high temperature insulation.
- B. Provide insulation with vapor barrier when air conveyed may be below ambient temperature.
- C. Exterior Insulation (Type A or Type B) Application:
- Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket. Apply glass fabric jacket between coats of weather barrier mastic, providing a smooth outside finish.
 - Secure insulation without vapor barrier with staples, tape, or wires.
 - Install without sag on underside of ductwork. Use adhesive or mechanical fasteners where necessary to prevent sagging. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.
- D. Duct Liner (Type D) Application:
- All duct liner shall be held in place by applying fire resistance 3M adhesive over 90% of the metal surface and then pressing insulation firmly in place. The liner surface designated to be exposed shall face the air stream. Ductwork 18" wide and over shall have the duct liner additionally secured by weld secured pins and clips and shall be fabricated and installed in accordance with SMACNA HVAC Duct Construction Standards.
 - Unless otherwise indicated, the net free area of the duct dimensions shown on the drawings shall be maintained. Installing two layers of material to meet the minimum liner thickness is not allowed. The duct dimensions shall be increased as necessary to compensate for liner thickness.
 - All edges of duct liner facing the direction of airflow shall either receive a metal nosing strip or shall be coated with the insulation manufacturer's approved adhesive. Liner shall be neatly butted without gaps at traverse joints and shall be coated with adhesive at such joints.
 - Liner shall be folded and compressed in the corners of rectangular duct sections or shall be cut and fit to assure butted edge overlapping. Longitudinal joints shall not occur except at corners of ducts.
 - Where dampers, turning vanes or other devices are placed inside of lined ductwork or fittings, the Installation must not damage the liner or cause erosion of the liner.
 - Ductwork exposed to the weather shall be made waterproof by sealing all seams with hardcast tape, applied according to manufacturer's recommendations. As additional weather protection, apply a coat of aluminum paint to all of the tape.

E. Continue insulation with vapor barrier through penetrations.

3.03 SCHEDULE

<u>DUCTWORK TYPE</u>	<u>TYPE</u>	<u>THICKNESS</u>	<u>FINISH</u>
Exhaust Ductwork within 10 ft. of exterior opening.	B	2"	FSK
Relief Ductwork within 10 ft. of exterior opening.	B	2"	FSK
Exhaust or Relief Ductwork in Attic Space	B	2"	FSK
Combustion Air Ductwork	B	2"	FSK
Outside Air Intake and Plenums	C	2"	(See 2.1, C)
Equipment Casings	Factory Insulated		
Return Ductwork located in unconditioned spaces	B	1 ½"	FSK
Supply Ductwork - Concealed	A	1 ½"	- -
Supply Ductwork - Exposed	Not Insulated unless located in non-ambient conditions		

END OF SECTION

SECTION 23 07 01

HVAC PIPING INSULATION

PART 1 GENERAL

1.01 SCOPE

- A. All work in this section is subject to the provisions of the General HVAC Requirements, and all other parts of the Contract Documents applicable to this Section of Work.

1.02 WORK INCLUDED

- A. Materials
- B. Insulation
- C. Jackets
- D. Insulation Inserts and Pipe Shields
- E. Fittings
- F. Flanges and Valves
- G. Vapor Barrier
- H. Accessories

1.03 RELATED WORK

- A. Section 23 05 00 – General HVAC Requirements
- B. Section 23 05 03 – Pipe and Fittings
- C. Section 23 05 29 – Supports and Anchors

1.04 REFERENCES

- A. ANSI/ASTM C195 - Mineral Fiber Thermal Insulation Cement
- B. ANSI/ASTM C547 - Mineral Fiber Preformed Pipe Insulation
- C. ANSI/ASTM C552 - Cellular Glass Block and Pipe Thermal Insulation
- D. ASTM C449 - Mineral Fiber Hydraulic-setting Thermal Insulating and Finishing Cement

E. NFPA 255 - Surface Burning Characteristics of Building Materials

1.05 QUALITY ASSURANCE

A. Applicator: Company specializing in piping insulation application with three (3) years' minimum experience.

1.06 SUBMITTALS

A. Submit product data under provisions of Section 23 05 00.

B. Include product description, list of materials and thickness for each service, and locations.

C. Submit manufacturer's installation instructions under provisions of Section 23 05 00.

PART 2 PRODUCTS

2.01 MATERIALS

A. Materials or accessories containing asbestos are not acceptable for use on this project.

B. Flame spread/fuel contributed/smoke developed rating in accordance with NFPA 255, max. flame spread rating of 25, max. smoke developed rating of 50.

2.02 INSULATION

A. Acceptable Manufacturers: Armstrong, Owens-Corning, Certainteed, Manville or Knauf

B. Materials shall be fire retardant, moisture and mildew resistant, and vermin proof. Insulation shall be suitable to receive jackets, adhesives and coatings as indicated.

C. Type A: Glass fiber insulation; ANSI/ASTM C547 'k' value of 0.29 at 75° F mean temperature, noncombustible. Insulation shall have an all service jacket with self-sealing lap.

D. Type B: Flexible closed-cell elastomeric thermal insulation, black in color, AP Armaflex 25/50 rated as tested by ASTM E 84. Insulation shall have a 'k' factor of 0.27 at 75° F mean temperature.

E. Type CI: Block and pipe covering insulation

1. Hydrous calcium silicate, ASTM C533, Type I, suitable for temperatures to 1,200 deg. F. Material to be visually coded or marked to indicate it is asbestos free. Thermal conductivity shall not be more than 0.44 at 300° F., with dry density 12.5 lbs. per cu. ft. minimum.

2. Provide jacket of 6 oz. per sq. yd. fiberglass cloth embedded in two (2) coats of weatherproof mastic.

F. Type CII:

1. Hydrous calcium silicate, ASTM C533, Type II, suitable for temperatures to 1,800 deg. F. Material to be visually coded or marked to indicate it is asbestos free. Thermal conductivity shall not be more than 0.44 at 300° F., with dry density 12.5 lbs. per cu. ft. minimum.
2. Provide jacket of 6 oz. per sq. yd. fiberglass cloth embedded in two (2) coats of weatherproof mastic.

G. Type D: Expansion joint insulation

1. Ceramic wool, 1" thick, 6 lb. density, thermal conductivity shall not be more than 0.50 at 400° F. mean temperature.
2. The jacket shall be silicone coated fiberglass cloth of 15 oz. per sq. yd. with a 4 harness satin weave and 0.069 Kevlar thread. Fabric shall meet the requirements of MIL-Y-1140H.

2.03 JACKETS

A. Interior Applications:

1. Piping Vapor Barrier Jackets: Kraft reinforced foil vapor barrier with self-sealing adhesive joints.
2. Fitting PVC Jackets: One piece, premolded type, Zeston pre-molded Hi-Lo temperature PVC insulation fitting.

B. Exterior Applications

1. Provide .016" thick aluminum or .010 inch thick stainless steel with safety edge on all piping exposed to the weather.

2.04 INSULATION INSERTS AND PIPE SHIELDS

- A. Provide insulation inserts and pipe shields at all hanger and support locations. Inserts may be omitted on 2" piping or smaller provided 12" long 22 ga. pipe shields are used.

- B. Construct inserts with calcium silicate, minimum 140 psi compressive strength. Piping 12" or larger, supplement with high density 600 psi structural calcium silicate inserts. Provide galvanized steel shields. Insert and shield to be minimum 180 degree coverage on bottom supported piping and full 360 degree coverage on clamped piping. On roller mounted piping and piping designed to slide on support, provide additional load distribution steel plate.

- C. Shop fabricated inserts and shields may be used provided contractor submits schedule of materials, thicknesses, gauges and length for each pipe size to demonstrate equivalency to pre-engineered/pre-manufactured products described above.

D. Wood blocks will not be accepted.

2.05 FITTINGS

A. All fittings shall be insulated with molded or pre-fabricated type insulation. Insulation for fittings shall be of same type materials and equal in thickness to the adjacent pipe insulation. Provide jackets of same type materials as adjacent pipe insulation.

B. Fittings should be carefully fitted and firmly wired in place. Wire must be looped as many times as necessary to make the installation secure.

C. Insulating cement shall be used to point up the insulation and to fill voids and cracks.

2.06 FLANGES AND VALVES

A. All flanges and valves shall be insulated in all hot water, steam and anti-sweat applications. Insulation shall be same as specified for fitting insulation. Insulation on flanges shall extend at least 2" over adjacent pipe insulation. Valve bodies shall be insulated up to the packing gland. The insulation shall not interfere with the adjustment or removal or packing glands and shall be sealed to valve body with sealer.

2.07 VAPOR BARRIER

A. All piping, fittings, flanges and valves in anti-sweat applications must have a vapor barrier seal. A coat of vapor barrier mastic shall be applied with enforcing cloth tightly stretched over the insulation and thoroughly embedded in the wet coating. Joints shall overlap a minimum of 2". Total dry thickness of both coats of mastic shall not be less than 1/16" thickness. The finish coat of mastic shall fully cover the membrane fabric so there are no voids.

B. Any molding of finished insulation within the first year after acceptance will warrant rejection. Contractor shall bear all costs to replace affected insulation.

2.08 ACCESSORIES

A. All products shall be compatible with surfaces and materials on which they are applied, and shall be suitable of use at operating temperatures of the systems to which they are applied.

B. Adhesives, sealants and protective finishes shall be as recommended by insulation manufacturer for applications specified.

C. Tack fasteners to be stainless steel ring grooved shank tacks.

D. Staples to be clinch style.

- E. Insulating cement to be ANSI/ASTM C449, hydraulic setting mineral wool.
- F. Finishing cement to be ASTM C449
- G. Fibrous glass or canvas fabric reinforcing shall have a minimum untreated weight of 6 oz./sq. yd.
- H. Bedding compounds to be non-shrinking and permanently flexible.
- I. Vapor barrier coatings to be non-flammable, fire resistant.

PART 3 EXECUTION

3.01 PREPARATION

- A. Install materials after piping has been tested and approved.

3.02 INSTALLATION

- A. Install insulation, jackets and accessories in accordance with manufacturer's instructions and under ambient temperatures and conditions recommended by the manufacturer. Surfaces to be insulated must be clean and dry prior to installation of insulation.
- B. Continue insulation with vapor barrier through penetrations.
- C. Do not insulate over equipment nameplates.
- D. Install insulation continuous through pipe hangers and supports with hangers and supports on the exterior of insulation. Where riser clamps are required to be attached directly to piping requiring vapor barrier, extend insulation and vapor barrier jacketing/coating around riser clamp.
- E. Install insulation with butt joints and longitudinal seams closed tightly. Provide minimum 2" lap on jacket seams and 2" tape on butt joints, firmly cemented with lap adhesive. Additionally, secure with staples along seams and butt joints. Coat all staples with vapor barrier mastic on systems requiring vapor barrier.
- F. Do not insulate systems or equipment which are specified to be pressure tested or inspected, until testing, inspecting and necessary repairs have been successfully completed.
- G. Install insulation with smooth even surfaces. Provide neatly beveled and coated terminations at all nameplates, uninsulated fittings, or at other locations where insulation terminates.
- H. All AP Armaflex insulation butt joints and seams are to be sealed with Armstrong 520 adhesive. Both surfaces to be joined shall be coated with adhesive.

I. On outdoor applications, a weather-resistant protective finish shall be applied.

J. Neatly finish insulation at supports, protrusions, and interruptions.

K. Jackets:

1. Indoor, Concealed Applications: Insulated pipes conveying fluids above ambient temperature shall have white all-service jackets, with or without vapor barrier, factory-applied or field-applied. PVC jackets may be used.

2. Indoor, Concealed Applications: Insulated dual-temperature pipes or pipes conveying fluids below ambient temperature shall have vapor barrier jackets, factory-applied or field-applied. PVC jackets may be used.

3. Indoor, Exposed Applications: For pipe exposed in mechanical equipment rooms or in finished spaces, insulate as for concealed applications. Finish with white all-service jacket; size for finish painting. PVC jackets may be used.

3.03 INSULATION SCHEDULE

<u>Piping</u>	<u>Type</u>	<u>Pipe Size (inches)</u>	<u>Insulation Thickness (inches)</u>
Refrigerant Suction	B	1" and smaller	1 1/2"
		1 1/4" and larger	1 1/2"
	A	8" and larger	3"

END OF SECTION

SECTION 23 09 93

SEQUENCE OF OPERATION

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and General Provisions of the contract, including General and Supplementary Conditions and Division 01 specification sections apply to work of this Section.

1.02 RELATED WORK

- A. 23 09 00 Building Automation System

1.03 GENERAL ITEMS

- A. The BAS and Mechanical Contractors shall reference Section 23 09 00 for the requirements of all control programs and controls related hardware and devices.
- B. All systems shall reference a global outdoor air temperature sensor.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 ENERGY RECOVERY VENTILATORS

- A. Control Programs
 - 1. CO2 occupancy sensor
- B. Control Sequence
 - 1. DDC CONTROLLER:
 - a. Controller with integral LCD readout for changing set points and monitoring unit operation.
 - b. Provided with required sensors and programming.
 - c. Factory programmed, mounted, and tested.
 - d. Integral USB and Ethernet ports for updating programs and retrieving log files.
 - 2. BMS INTERFACE:
 - a. BACnet MS/TP
 - b. BACnet IP
 - c. Modbus RTU
 - d. Modbus TCP
- C. Control Devices
 - 1. CO₂ FLOW CONTROL OPTION:

- a. The controller will adjust the supply fan VFD command based on the measured room or return air CO₂ level. The supply air flow set point is derived from the user entered minimum and maximum CO₂ levels and minimum and maximum desired air flow rates. When the CO₂ level is at or below the minimum CO₂ level the air flow set point is at the minimum and when the CO₂ level is at or above the maximum CO₂ level the air flow set point is at the maximum. Between the minimum and maximum CO₂ levels the air flow set point is linearly scaled. If the measured CO₂ level exceeds 1000 ppm (adjustable) for more than 60 seconds (adjustable) a CO₂ alarm will be set to true. This supply fan operation mode can be used to provide demand controlled ventilation of a space. The minimum fan speed will provide the required minimum outdoor air when the CO₂ level is at or below the CO₂ set point.

3.02 CABINET HEATER

- A. Control programs
1. Scheduled occupied/unoccupied.
 2. Dead band.
 3. Night set-back.
- B. Control devices for each unit.
1. Application Specific Controller.
 2. Room temperature sensor – Plain cover type.
 3. Two-way heating coil valve and modulating actuator.
 4. Outputs for fan motor control.
- C. Control Sequence.
1. The DDC control program shall cycle the unit fan motor and modulate the heating coil valve to maintain room temperature setpoint.

3.03 SPLIT SYSTEM

- A. The control system shall consist of two microprocessors, one on each indoor and outdoor unit, interconnected by a single non-polar two-wire cable.
- B. The system shall be capable of automatic restart when power is restored after power interruption, the system shall have self-diagnostic ability, including total hours of compressor run time. Diagnostic codes for indoor and outdoor units shall be displayed on the wired controller panel.
- C. The microprocessor located in the indoor unit shall have the capability of monitoring return air temperature and indoor coil temperature receiving and processing commands from the wired controller, providing emergency operation and controlling the outdoor unit.

3.04 IN-LINE EXHAUST FANS – MANUAL CONTROL WITH UNOCCUPIED OFF

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SECTION 23 31 00

DUCTWORK

PART 1 GENERAL

1.01 WORK INCLUDED

- A. Metal ductwork
- B. Flexible ductwork
- C. PVC ductwork
- D. Fiberglass reinforced plastic ductwork
- E. Underground ductwork
- F. Casings
- G. Duct cleaning
- H. Duct leak testing
- I. Kitchen hood ductwork
- J. Kitchen exhaust hood

1.02 RELATED WORK

- A. Section 23 05 29 - Supports and Anchors: Sleeves
- B. Section 23 05 93 - Testing, Adjusting and Balancing
- C. Section 23 07 00 - Ductwork Insulation
- D. Section 23 33 00 - Ductwork Accessories
- E. Section 23 37 00 - Air Outlets and Inlets

1.03 REFERENCES

- A. ASHRAE - HVAC Systems and Equipment Handbook; Chapter 16 – Duct Construction
- B. ASTM A 90 - Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles

- C. ASTM A167 - Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet and Strip
- D. ASTM A 366 - Steel, Sheet, Carbon, Cold Rolled, and Commercial Quality
- E. ASTM A 525 - General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
- F. ASTM A 527 - Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality
- G. ASTM B209 - Aluminum and Aluminum Alloy Sheet and Plate
- H. NBS PS15-69 - Standard for Construction and Testing for Products Intended for use in Aggressive Chemical Environments
- I. NFPA 90A - Installation of Air Conditioning and Ventilating Systems
- J. NFPA 96 - Ventilation Control and Fire Protection of Commercial Cooking Operations
- K. SMACNA - HVAC Air Duct Leakage Test Manual
- L. SMACNA - HVAC Duct Construction Standards – Metal and Flexible
- M. SMACNA - Thermoplastic Duct (PVC) Construction Manual
- N. UL 181 - Factory Made Air ducts and Connectors

1.04 SUBMITTALS

- A. Submit under provisions of Section 01 30 00.
- B. Shop Drawings and Product Data:
 - 1. Indicate types of flexible ductwork to be used. Include data sheets and installation instructions.
 - 2. Provide manufacturer's data sheets for factory-fabricated ductwork and fittings. Include information on materials of construction, wall thickness, fitting construction, pressure class, joint construction, sealing, and assembly and installation instructions.
 - 3. Provide manufacturer's data sheets for proprietary duct connection system components. Include information on flange construction, duct wall gauge requirements, fastening hardware, gasketing, fittings, and assembly and installation instructions.

PART 2 PRODUCTS

2.01 MATERIALS

- 1 A. Aluminum Ducts: ASTM B209; aluminum sheet, alloy 3003-H14. Aluminum
2 connectors and Bar Stock; Alloy 6061-T6 or of equivalent strength.
- 3 B. Flexible Ductwork:
- 4 1. Return or Exhaust Applications:
- 5 a. UL 181, Class 1 air duct material constructed of
6 impregnated/coated woven fiberglass cover permanently bonded to
7 a coated spring wire helix or flat steel bands.
- 8 b. Pressure Rating: 16" WG positive and 2.0" WG negative
- 9 c. Maximum Velocity: 5000 fpm
- 10 d. Temperature Range: 0° F to 200° F continuous
- 11 e. Manufacturer: Thermaflex S-TL or approved equal
- 12 2. Low Pressure Supply Air Applications (Downstream of VAV Units):
- 13 a. UL 181, Class 1 air duct material constructed of a vinyl or
14 polymeric inner duct permanently bonded to a coated spring wire
15 helix or flat steel bands.
- 16 b. Insulation: 1" thick, 1 lb. Density, flexible glass fiber insulation,
17 enclosed by a seamless, fiberglass reinforced, aluminized vapor
18 barrier jacket. Insulation K value of 0.23 or less at 75° F
- 19 c. Pressure Rating: 10" WG positive and 1.0" WG negative
- 20 d. Maximum Velocity: 3000 fpm
- 21 e. Temperature Range: 0° F to 200° F continuous
- 22 f. Manufacturer: Thermaflex M-KE or approved equal
- 23 C. Fiberglass Reinforced Plastic Ductwork: NBS PS15-69 contact molded, glass
24 fiber reinforced ducting and fittings as manufactured by Viron International
25 Corporation, Peabody Spunstrand, or prior approved equal.
- 26 D. Fasteners: Rivets, bolts, or sheet metal screws.
- 27 E. Sealant: Non-hardening, water resistant, fire resistive, compatible with mating
28 materials; liquid used alone, with tape, or with heavy mastic.
- 29 F. Ductwork Support Materials:
- 30 1. Hot-dipped galvanized fasteners, anchors, hanger rods, straps, trim and
31 angles shall be used to support ductwork.
- 32 2. Hanger Rod: ASTM A36; threaded both ends, threaded one end, or
33 continuously threaded.
- 34 3. Support stainless steel ductwork with matching stainless steel support
35 materials.
- 36 4. Support aluminum ductwork with aluminum support materials or with
37 materials electrolytically isolated from the ductwork.

38 2.02 DUCTWORK FABRICATION

- 1 A. Fabricate and support in accordance with SMACNA HVAC Duct Construction
2 Standards – Metal and Flexible, and as indicated. Provide duct material, gauges,
3 reinforcing, and sealing for operating pressures indicated. Exposed galvanized
4 metal ductwork shall be constructed of paintable sheet metal.
- 5 B. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of
6 duct on centerline. Where not possible and where rectangular elbows are used,
7 provide turning vanes. Where acoustical lining is indicated, provide turning
8 vanes of perforated metal with glass fiber insulation.
- 9 C. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever
10 possible; maximum 30 degrees divergence upstream of equipment and 45 degrees
11 convergence downstream.
- 12 D. Fabricate continuously welded round and oval duct fittings two (2) gauges heavier
13 than duct gauges indicated in SMACNA Standard. Joints shall be minimum 4”
14 cemented slip joint, continuous welded, or spot-welded and sealed. Prime coat
15 welded joints.
- 16 E. Provide standard 45-degree lateral wye or 90 degree conical tee fittings at branch
17 connections to round duct mains. Provide 45-degree entry or conical fittings at
18 branch connections to rectangular duct mains.

19 2.03 MANUFACTURED DUCTWORK AND FITTINGS

- 20 A. Ductwork and fittings shall be factory fabricated in accordance with SMACNA
21 HVAC Duct Construction Standards – Metal and Flexible, and as indicated.
22 Provide duct material, gauges, reinforcing, and sealing as required for operating
23 pressures indicated. Contractor fabricated ductwork meeting the specified
24 construction standards shall be acceptable with prior approval of the
25 Architect/Engineer. Submit construction details, materials used, type or service,
26 reinforcing methods, and sealing procedures for prior approval.
- 27 B. Manufacturers: Foremost Duct, Inc., Semco, and United-McGill.
- 28 C. Round/Flat Oval Ductwork: Machine made from round spiral lockseam duct with
29 light reinforcing corrugations; fittings manufactured of at least two (2) gauges
30 heavier metal than duct. Longitudinal welded seam duct shall be used where
31 diameters exceed 84” or for metal gauges where spiral duct is unavailable.
- 32 D. Double-Wall Insulated Ductwork: Outer shell gauge shall be based on the actual
33 outer shell dimensions. Duct diameter indicated on drawings is the liner
34 dimension. Inner liner shall be constructed of solid [or perforated] sheet metal
35 gauge based on manufacturer’s recommendations for size of duct indicated.
36 Space between inner liner and outer duct to be filled with 1” thick glass fiber
37 insulation.
- 38 E. Ductwork shall be constructed of paintable galvanized sheet metal.

2.04 TRANSVERSE JOINT DUCT CONNECTION SYSTEMS

- A. Rectangular, round, or oval ductwork systems using proprietary slid-on flanges as manufactured by Ductmate may be used at Contractor's option. Rectangular ductwork with side dimensions of 42" or larger shall be joined with a Ductmate System.
- B. Transverse joints shall be constructed per SMACNA, non-proprietary, T-22 reinforcement standards, Type "J" rigidity class. System includes 20 gauge roll formed slid-on flange with integral sealant, gasketing, cleats, and corner clips.
- C. Rectangular transverse joint duct connection systems utilizing proprietary formed on flanges (formed from the ends of the duct walls) may be used at Contractor's option on rectangular ductwork with side dimensions of 40" or smaller. Formed on flange joints shall be limited to ductwork systems constructed for 2" maximum static pressure (positive or negative).

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install and seal ductwork in accordance with SMACNA HVAC Duct Construction standards – Metal and Flexible.
- B. Fibrous glass ductwork may "not" be substituted for internally or externally insulated or uninsulated low pressure sheet metal ductwork.
- C. Do not install duct sealant when temperature is less than those recommended by sealant manufacturers. Maintain temperatures during and after installation of duct sealant.
- D. Verify dimensions at the site, making field measurements and drawings necessary for fabrication and erection. Check plans showing work of other trades and consult with Architect/Engineer to resolve interferences.
- E. Seal ductwork joints, seams and duct wall penetrations, of systems located external to conditioned spaces, in accordance with SMACNA seal class recommended for pressure class indicated.
- F. All ductwork serving general exhaust systems shall be sealed with Sure-Bond No. 188 Clear Silicone.
- G. Construct and install ductwork to NFPA 90A standards.
- H. Duct sizes indicated on the drawings are inside clear dimensions.

- I. No variation of duct configuration or sizes permitted except by prior approval of Architect/Engineer. Size round ducts installed in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular and round ducts.
- J. Provide frames constructed of angles or channels for coils, filters, dampers or other devices to be installed in the duct systems. Make all connections to such equipment, including equipment furnished by others. Install sheet metal close-off fabrications to prevent air bypass around channel mounted equipment. Fasten close-off sheets to interior plenum or casing wall and equipment support channels.
- K. Set plenum or casing doors 6" to 12" above floor. Arrange door swing so that fan static pressure holds door in closed position.
- L. Provide supplementary auxiliary steel members required to support ductwork. Attach to building structure. Attach steel members by or clamping.
- M. Install all motor operated dampers and connect to or install all duct-mounted equipment furnished by other trades.
- N. Branch ductwork shall be provided for all air outlets and inlets and shall be constructed with sufficient length to contain the grille plus any damper, in fully open position, without obstructing main duct air flow.
- O. Round or oval ductwork exposed in occupied finished areas shall be free from dents and scratches, and duct sealant applied shall have a smooth, finished appearance.
- P. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pitot tube openings where required for testing of systems, complete with metal cap with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
- Q. Where ductwork penetrates interior partitions, floors, and exterior walls, pack the annular space with insulation and conceal the space between opening and duct or duct insulation with sheet metal flanges of same gauge as duct. Where ducts pass through fire-rated floors, walls or partitions, provide fire stopping between duct and opening.
- R. Ductwork connecting to louvers shall pitch toward the louver and drain outside the building. Solder or seal duct seams near the louvers to form watertight joints.
- S. Blank off all unused portions of louvers with 1-1/2" rigid insulation. Provide galvanized sheet metal backing on both sides of insulation. Paint sheet metal backing visible through the louver matte black.
- T. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

- U. Do not install ductwork through dedicated electrical or elevator equipment rooms or spaces unless the ductwork is serving the room or space.
- V. Pitch exhaust ductwork serving high moisture areas or moisture generating equipment to drain back to the exhaust grille or equipment served.
- W. Use double nuts and lock washers on threaded rod supports.
- X. Connect diffusers to ductwork with 5' maximum length of flexible duct.
- Y. Connect flexible ducts to metal ducts with stainless steel draw bands and per ductwork manufacturers written instructions.
- Z. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.

3.02 CLEANING

- A. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.

3.03 DUCTWORK APPLICATION SCHEDULE

<u>AIR SYSTEM</u>	<u>MATERIAL</u>	<u>PRESSURE CLASS</u>
Constant Volume Supply	Galvanized Steel, Aluminum	2.0"
Return and Relief	Galvanized Steel, Aluminum	4.0"
General Exhaust	Galvanized Steel, Aluminum	2.0"
Outside Air Intake	Galvanized Steel	2.0"
Combustion Air	Galvanized Steel, Aluminum	2.0"

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SECTION 23 33 00

DUCTWORK ACCESSORIES

PART 1 GENERAL

1.01 WORK INCLUDED

- A. Volume control dampers
- B. Backdraft dampers
- C. Automatic control dampers
- D. Air turning devices
- E. Flexible duct connections
- F. Duct access doors
- G. Duct test holes
- H. Acoustic flexible duct
- I. Access panels

1.02 RELATED WORK

- A. Section 23 05 93 - Testing, Adjusting and Balancing
- B. Section 23 31 00 - Ductwork
- C. Section 23 37 00 - Air Outlets and Inlets

1.03 REFERENCES

- A. AMCA 503-93 - Fire, Ceiling and Smoke Dampers Application Manual
- B. NFPA 90A - Installation of Air Conditioning and Ventilating Systems
- C. NFPA 92A - Smoke Control Systems
- D. SMACNA - HVAC Duct Construction Standards – Metal and Flexible
- E. UL 33 - Heat Responsive Links for Fire-Protection Service
- F. UL 181 - Factory Made Air Ducts and Air Connectors
- G. UL214 - Tests for Flame Propagation of Fabrics and Films

H. UL 555 - Fire Dampers and Ruskin Ceiling Dampers

I. UL 555C - Ceiling Radiation Dampers

J. UL 555S - Smoke Dampers

1.04 SUBMITTALS

A. Submit under provisions of Section 23 05 00:

1. Product Data and Shop Drawings: Indicate pertinent dimensions, general construction, component connections and details, anchorage methods, hardware location, and installation details.

2. Installation Instructions: Provide manufacturer's installation instructions. Provide UL listed installation instructions for all fire dampers and smoke dampers.

PART 2 PRODUCTS

2.01 VOLUME CONTROL DAMPERS FOR ACCESSIBLE CEILING

A. Acceptable Manufacturers: Greenheck, Ruskin, CESCO, and Air Balance

B. Provide manual balancing dampers in accordance with SMACNA Duct Construction Standards except where the following requirements are more stringent.

C. Provide single bladed dampers for damper sizes less than 36" wide by 12" high. Frames for single bladed dampers shall be galvanized steel minimum 20 gauge.

D. Provide opposed blade dampers with maximum blade size of 48" wide by 6" high. Frames for multi-blade dampers shall meet or exceed SMACNA thickness requirements and shall have blade linkage concealed in the jamb.

E. Damper blades shall meet or exceed SMACNA thickness requirements and shall be reinforced with three (3) structural vee's.

F. Except in round balancing dampers, 12" diameter and under, provide oil impregnated end bearings.

G. Provide vinyl end bearings in all round dampers 12" diameter and under.

H. Provide manual locking, indicating hand quadrant. On dampers wider than 30", provide a hand quadrant at each end. On insulated ducts mount hand quadrant on a formed standoff bracket.

2.02 VOLUME CONTROL DAMPERS FOR UN-ACCESSIBLE CEILING

A. Acceptable Manufacturer: Young Regulator.

- B. Provide manual balancing dampers in accordance with SMACNA Duct Construction Standards except where the following requirements are more stringent.
- C. Provide round duct dampers constructed of heavy duty galvanized steel spiral frame.
- D. Damper blades shall be “V” style 20 gauge galvanized steel blade secured with ½” diameter steel shaft and Teflon bushings that require no lubrication.
- E. Include all necessary hardware to ensure compatibility with Bowden remote cable control system.
- F. Provide damper controller and cable to allow damper operation from occupied space. Cable to consist of Bowden cable .054” stainless steel control wire encapsulated in 1/16” flexible galvanized spiral sheath.
- G. Control kit shall include 2-5/8” diameter die cast aluminum housing with 3” diameter zinc plated cover, 14 gauge steel rack and pinion gear drive. Cover is to be painted to match ceiling.

2.03 BACKDRAFT DAMPERS.

- A. Acceptable manufacturer: Greenheck, CESCO, and Ruskin
- B. Provide gravity counterbalanced backdraft dampers; size as indicated on the drawings.
- C. Damper blades shall be 6063T5 extruded aluminum, .050” wall thickness, with extruded vinyl blade seals. Blade linkages shall be aluminum. Blade end bearings shall be nylon.
- D. Damper frame shall be 6063T5 extruded aluminum, 4” wall thickness.

2.04 AUTOMATIC CONTROL DAMPERS

- A. Acceptable Manufacturers: Greenheck, Air Balance, CESCO, and Ruskin.
- B. Provide opposed blade control damper of the 100% shut-off type. Maximum leakage at a differential pressure of 4” w.g. across the damper shall be 10 CFM per square foot of damper area.
- C. Damper blades shall be minimum 16 gauge galvanized steel with three (3) longitudinal vee type grooves for reinforcement. Blade linkages shall be concealed in the frame of the damper. Blade end bearings shall be oil-impregnated bronze.

- D. Blade edge seals shall be silicone rubber and have a flame spread rating less than 25 and a smoke developed rating less than 50. Seals shall provide a tighter seal against leakage as pressure across the damper increases.
- E. Damper frame shall be 16 gauge galvanized steel formed into a hat channel with reinforced corners. A low profile head and sill must be incorporated on all dampers less than 17" high. Jamb seals shall be stainless steel compression type.

2.05 AIR TURNING DEVICES

- A. Acceptable Manufacturers: Aero Dyne, Anemostat, and Hart & Cooley
- B. Shop fabricated turning vanes are not acceptable.
- C. Use only steel or aluminum airfoil type vanes and construct in accordance with SMACNA Fig. 2-3 and Fig. 2-4.
- D. Construct vanes for short radius elbows and elbows where one dimension changes in the turn in accordance with SMACNA Fig. 2-5 and Fig. 2-6.

2.06 FLEXIBLE DUCT CONNECTIONS

- A. Acceptable Manufacturers: Ventfabrics or an approved equal.
- B. Provide connections that are fire retardant, UL214 listed, and meet all requirements of NFPA 90A.
- C. Connection shall be constructed of a glass fiber fabric with a 3" minimum width. This fabric shall be manufacturer supplied connected airtight to two 3" minimum width metal edging strips.
- D. Flexible connections installed in interior non-corrosive applications shall be double coated with Neoprene (polychloroprene) and shall be suitable for temperatures ranging from -10° F to 200° F. Fabric shall have a nominal weight of 30 oz. per square yard.
- E. Flexible connections installed in exterior non-corrosive applications shall be double coated with DuPont Hypalon (chlorosulfurated polyethylene) and shall be suitable for temperatures ranging from -10° F to 275° F. Fabric shall have a nominal weight of 26 oz. per square yard.
- F. Flexible connections installed in interior or interior or exterior corrosive environments shall be coated with DuPont Teflon and shall be suitable for temperatures ranging from -20° F to 500° F. Fabric shall have a nominal weight of 14 oz. per square yard. Do not use flexible connections on kitchen exhaust systems.

2.07 DUCT ACCESS DOORS

- 1 A. Provide access doors constructed in accordance with SMACNA HVAC Duct
2 Construction Standards Figs. 2-12 and 2-13 except where the following is more
3 restrictive.
- 4 B. Construction of doors shall be suitable for the pressure class of the duct in which
5 they are to be installed. Materials of construction to be identical to adjacent
6 ductwork. All access doors shall be sealed with a material that has a flame spread
7 rating less than 25 and a smoke developed rating less than 50.
- 8 C. Provide minimum 1" thick insulated doors when installed in insulated ductwork.
9 Insulation shall be completely covered with door metal.
- 10 D. Access doors smaller than 12" square may be secured with cam sash locks.
11 Access doors larger than 12" square must be provided with continuous piano
12 hinge and two (2) cam sash locks for sizes up to 24" x 36". Provide additional
13 dual acting handles for larger sizes.
- 14 E. Shop fabricated access doors and doors constructed with sheet metal screw
15 fasteners are not acceptable.

16 2.08 DUCT TEST HOLES

- 17 A. Cut or drill temporary test holes in ducts as required. Cap with neat patches,
18 neoprene plugs, threaded plugs, or threaded or twist-on metal caps.
- 19 B. Permanent test holes shall be factory fabricated, air tight flanged fittings with
20 screw cap. Provide extended neck fittings to clear insulation.

21 2.09 ACOUSTIC FLEXIBLE DUCT

- 22 A. Acceptable Manufacturers: Clevaflex Type DB and Thermaflex Type MK-E.
- 23 B. Provide factory fabricated UL 181 Class I flexible duct with a flame spread rating
24 of 25 or less and a smoke developed rating of 50 or less.
- 25 C. Provide ductwork with a minimum 1" fiberglass insulation blanket with a
26 minimum density of $\frac{3}{4}$ lb. per cubic foot and a vapor barrier jacket of
27 polyethylene or metalized reinforced film laminate. Maximum vapor
28 transmission rating or vapor barrier jacketed to be 0.1 perm.
- 29 D. Ductwork shall be capable of maintaining a round shape without sagging or
30 drooping.

31 2.10 ACCESS PANELS

- 32 A. Acceptable Manufacturers: Milcor and Cesco

SECTION 23 34 01

IN-LINE FANS

PART 1 GENERAL

1.01 WORK INCLUDED

- A. In-line centrifugal fans
- B. Ceiling exhaust fans
- C. Motors and drives
- D. Discharge dampers
- E. Belt guards
- F. Access doors

1.02 RELATED WORK

- A. Section 23 05 13 - Motors and Starters
- B. Section 23 31 00 - Ductwork
- C. Section 23 33 00 - Ductwork Accessories: Automatic control Dampers

1.03 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Section 23 05 00.
- B. Provide product data on centrifugal fans and accessories as required for the work.
- C. Provide fan curves with specified operating point clearly plotted.

1.04 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Section 23 05 00.
- B. Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to site under provisions of Division 01.
- B. Store and protect products under provisions of Division 01.
- C. Protect motors, shafts, and bearings from weather and construction dust.

1 PART 2 PRODUCTS

2 2.01 IN-LINE FANS

- 3 A. Furnish and install in-line centrifugal fans of size, type, and capacity as shown
4 and scheduled on the drawings. Unit shall be Loren Cook or Greenheck.
- 5 B. All components shall be AMCA approved and capacities shall be AMCA rated
6 and bear the AMCA seal.
- 7 C. Units must have motor externally mounted with adjustable motor sheave and
8 base. Direct drive units shall be provided with speed controllers. Lubricating
9 tubes shall be provided from the shaft bearings to the fan housing for lubrication.
- 10 D. Units must have support brackets and spring vibration isolators. Fan shall be
11 equipped with a spun inlet Venturi, centrifugal fan wheel, insulated housing and
12 air flow outlet vanes. Fans must be provided with a totally enclosed belt guard,
13 ventilated properly for the horsepower of the motor and drive. Unit must have
14 square inlet and outlet duct connections.
- 15 E. Mount units as shown on the drawings and connect ductwork with flexible
16 connections. Lubricate fan and motor, check fan rotation, and adjust belts and
17 drives as required.

18 PART 3 EXECUTION

19 3.01 INSTALLATION

- 20 A. Do not operate fans for any purpose until ductwork is clean, filters are in place,
21 bearings lubricated, and fan has been test run under observation.
- 22 B. Install fans as specified, with resilient mountings and flexible electrical leads.
- 23 C. Install flexible connections specified in Section 23 33 00 between fan inlet and
24 discharge ductwork. Ensure metal bands of connectors are parallel with minimum
25 1" (25 mm) flex between ductwork and fan while running.
- 26 D. Provide safety screen where inlet or outlet is exposed.
- 27 E. Provide backdraft dampers or automatic dampers on inlet or discharge side of fans
28 as indicated.

29 END OF SECTION

1 SECTION 23 37 00

2 AIR OUTLETS AND INLETS

3 PART 1 GENERAL

4 1.01 SCOPE

- 5 A. All work in this section is subject to the provisions of the General HVAC
6 Requirements, and all other parts of the Contract Documents applicable to this
7 Section of Work.

8 1.02 WORK INCLUDED

- 9 A. Grilles and Diffusers

- 10 B. Wall Caps

11 1.03 REFERENCES

- 12 A. ANSI/NFPA 90A - Installation of Air Conditioning and Ventilating Systems

- 13 B. ASHRAE 70 - Method of Testing for Rating the Air Flow Performance of Outlets
14 and Inlets

- 15 C. SMACNA - Low Pressure Duct Construction Standard

16 1.04 SUBMITTALS

- 17 A. Submit product data under provisions of Section 23 05 00.

- 18 B. Provide product data for items required for this project.

- 19 C. Submit schedule of outlets and inlets indicating type, size, location, application,
20 and noise level.

- 21 D. Review requirements of outlets and inlets as to size, finish, and type of mounting
22 prior to submitting product data and schedules of outlets and inlets.

23 PART 2 PRODUCTS

24 2.01 GRILLES AND DIFFUSERS

- 25 A. Acceptable Manufacturers:

- 26 1. Titus
27 2. Price
28 3. MetalAire
29 4. Tuttle and Bailey

1 B. Louvered Face Ceiling Diffusers:

- 2 1. Square or rectangular louvered face ceiling diffusers shall consist of an
3 outer frame assembly with an integral square or rectangular inlet. A
4 transition piece shall facilitate attachment of a round duct.
5 2. An inner core assembly consisting of fixed deflection louvers shall be
6 available in 1, 2, 3, or 4-way horizontal discharge patterns. Diffuser shall
7 be constructed of 22 gauge steel or aluminum. Refer to schedule on
8 drawings for material construction type.
9 3. Unless specified otherwise, finishes shall be #26 white. Finish shall be an
10 anodic acrylic paint, baked at 315° F. The finish must pass a 250 hour
11 ASTM-870 water immersion test. The finish must also pass the ASTM D-
12 2794 Reverse Impact Cracking Test with a 50 inch pound force applied.
13 4. Provide T-bar mounting panel for lay-in mounting requirements. Provide
14 surface mount border for applicable surface mounting requirements when
15 required.
16 5. In special space restricted circumstances and only with Engineers
17 approval, a heavy gauge damper, mounted in the diffuser core may be
18 used. Damper must be operable from the face of the diffuser.
19 6. The manufacturer shall submit published performance data for the diffuser
20 at the conditions specified and scheduled. The manufacturer shall submit
21 published NC values at the conditions specified and scheduled. The
22 diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-
23 1991.

24 PART 3 EXECUTION

25 3.01 INSTALLATION

- 26 A. Install items in accordance with manufacturers' instructions.
- 27 B. Check location of outlets and inlets and make necessary adjustments in position to
28 conform with architectural features, symmetry, and lighting arrangement.
- 29 C. Install diffusers to ductwork with airtight connection.
- 30 D. Paint ductwork visible behind air outlets and inlets matte black.
- 31 E. Install roof hoods in location indicated on drawings. Coordinate roof openings
32 location and size with the General Contractor.
- 33 F. Furnish louvers for the General Contractor for mounting in exterior walls.
34 Connect ductwork to the louver, sealing all connections air and watertight.
- 35 G. Provide bird screen on inside of active louver area where none is provided with
36 louver. Where louvers are equipped with bird screen, remove screen at all
37 locations where duct connections are not made

1 H. Install insulated metal panel on unused portion of louver. Panels must be sealed
2 weather tight to louver assembly with flashing as required for proper drainage to
3 outside of building. Paint outside surface of panel to match louver prior to
4 installation. Where ductwork is visible through louver when viewed from outside
5 the building, paint inside of duct to match louver color.

6 END OF SECTION

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SECTION 23 72 00

ENERGY RECOVERY UNITS

PART 1 GENERAL

1.01 SUMMARY

- A. This section includes Air-to-Air Energy Recovery Ventilators installation.
- B. Within this document, these units may be referred to as Energy Recovery Ventilator (ERV) for brevity.

1.02 RELATED

- A. Drawing and general provisions of the contract, including General Requirements Division 01, Division 23, Division 23 Specifications Sections, and common work requirements for HVAC apply to work specified in this section.
- B. Section 23 09 93: Controls and Instrumentation

1.03 SUBMITTALS

- A. Product data: For each type or model of Energy Recovery Ventilator, include the following:
 - 1. Unit performance data for both Supply Air and Exhaust Air, with system operating conditions indicated.
 - 2. Enthalpy plate performance data for both summer and winter operation.
 - 3. Motor ratings and unit electrical characteristics.
 - 4. Dimensioned drawings for each type of installation, showing isometric and plan views, to include location of attached ductwork and service clearance requirements.
 - 5. Estimated gross weight of each installed unit.
 - 6. Filter types, quantities, and sizes
 - 7. Installation, Operating and Maintenance manual (IOM) for each model.
- B. LEED Submittals:
 - 1. Provide data for prerequisite E01: Documentation indicating that units comply with ASHRAE 62.1-2010, Section 5 - "Systems and Equipment".
- C. Shop Drawings: For air-to-air energy recovery ventilators, include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Wiring Diagrams: For power, signal, and control wiring.
- D. Operation and maintenance data for air-to-air energy recovery ventilator

1.04 QUALITY ASSURANCE

- A. Source Limitations: Obtain Air-to-Air Energy Recovery Ventilator with all appurtenant components or accessories from a single manufacturer.
- B. For the actual fabrication, installation, and testing of work under this section, use only thoroughly trained and experienced workers completely familiar with the items required and with the manufacturer's current recommended methods of installation.
- C. The ERV core shall be warranted to be free of manufacturing defects and to retain its functional characteristics, under circumstances of normal use, for a period of ten (10) years from the date of purchase. The balance-of-unit shall be warranted to be free of manufacturing defects and to retain its functional characteristics, under circumstances of normal use, for a period of two (2) years from the date of installation.
- D. Manufacturer shall be able to provide evidence of independent testing of the core by Underwriters Laboratory (UL), verifying a maximum flame spread index (FSI) of 25 and a maximum smoke developed index (SDI) of 50 thereby meeting NFPA90A and NFPA 90B requirements for materials in a compartment handling air intended for circulation through a duct system. The method of test shall be UL Standard 723.
- E. Certifications:
 - 1. The energy recovery cores used in these products shall be third party Certified by AHRI under its Standard 1060 for Energy Recovery Ventilators. AHRI published certifications shall confirm manufacturer's published performance for airflow, static pressure, temperature and total effectiveness, purge air (OACF) and exhaust air leakage (EATR). Products that are not currently AHRI certified will not be accepted. OACF shall be no more than 1.02 and EATR shall be at 0% against balanced airflow.
 - 2. Units intended for outdoor use shall be rain tested in accordance with UL 1812 Section 67.
- F. Every unit to be factory tested prior to shipping: Motor Dielectric Voltage-Withstand Bench Test, Unit Dielectric Voltage-Withstand Test, Continuity of External Control Circuits Test, Unit Amperage Test

1.05 COORDINATION

- A. Coordinate size and location of all building penetrations required for installation of each Energy Recovery Ventilator and associated electrical systems.
- B. Coordinate sequencing of construction for associated plumbing, HVAC, electrical supply.

- C. Coordinate sizes and locations of equipment supports with actual equipment provided.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with specifications contained within this document, manufacturers offering products that may be incorporated into the work include, but are not limited to:

1. RenewAire

- B. Manufacturer should be in business for minimum 10 years manufacturing energy recovery ventilators.

2.02 MANUFACTURED UNITS

- A. Air-to-Air Energy Recovery Ventilators shall be fully assembled at the factory and consist of a fixed-plate cross-flow heat exchanger with no moving parts, an insulated single wall G90 galvanized 20-gauge steel cabinet, motorized damper filter assemblies for both intake and exhaust air, enthalpy core, supply air blower assembly, motorized damper exhaust air blower assembly and electrical control box with all specified components and internal accessories factory installed and tested and prepared for single-point high voltage connection. Entire unit with the exception of field-installed components shall be assembled and test operated at the factory.

2.03 CABINET

- A. Materials: Formed single wall insulated metal cabinet, fabricated to permit access to internal components for maintenance.
- B. Outside casing: 20 gauge, galvanized (G90) steel meeting ASTM A653 for components that do not receive a painted finish.
- C. Access doors shall be hinged with airtight closed cell foam gaskets. Door pressure taps, with captive plugs, shall be provided for cross-core pressure measurement allowing for accurate airflow measurement.
- D. Unit shall have factory-installed duct flanges on all duct openings.
- E. Cabinet Insulation: Unit walls and doors shall be insulated with 1 inch, 4 pound density, foil/scrim faced, high density fiberglass board insulation, providing a cleanable surface and eliminating the possibility of exposing the fresh air to glass fibers, and with a minimum R-value of 4.3 (hr-ft²-°F/BTU).

- 1 F. Enthalpy core: Energy recovery core shall be of the total enthalpy type, capable of
2 transferring both sensible and latent energy between airstreams. Latent energy
3 transfer shall be accomplished by direct water vapor transfer from one airstream
4 to the other, without exposing transfer media in succeeding cycles directly to the
5 exhaust air and then to the fresh air. No condensate drains shall be allowed. The
6 energy recovery core shall be designed and constructed to permit cleaning and
7 removal for servicing. The energy recovery core shall have a ten year warranty.
8 Performance criteria are to be as specified in AHRI Standard 1060.
- 9 G. Control center / connections: Energy Recovery Ventilator shall have an electrical
10 control center where all high and low voltage connections are made. Control
11 center shall be constructed to permit single-point high voltage power supply
12 connections to the non-fused disconnect.
- 13 H. Passive Frost Control: The ERV core shall perform without condensing or
14 frosting under normal operating conditions (defined as outside temperatures
15 above -10°F and inside relative humidity below 40%). Occasional more extreme
16 conditions shall not affect the usual function, performance or durability of the
17 core. No condensate drains will be allowed.
- 18 I. Motorized Isolation Damper(s): Exhaust Air and Fresh Air motorized dampers of
19 an AMCA Class I leakage type shall be factory installed.

20 2.04 BLOWER SECTION

- 21 A. Blower section construction, Supply Air and Exhaust Air: Blower assemblies
22 consist of a 208 single phase 60 HZ, ECM motor, and a direct driven backward-
23 inclined blower.
- 24 B. Blower assemblies: Shall be statically and dynamically balanced and designed for
25 continuous operation at maximum rated fan speed and horsepower.

26 2.05 MOTORS

- 27 A. Blower motors shall be Premium Efficiency, EISA compliant for energy
28 efficiency. The blower motors shall be totally enclosed (TEFC) and be shall be
29 supplied with factory installed motor starters.

30 2.06 UNIT CONTROLS

- 31 A. Fan control: Onboard VFD
- 32 B. Sensors: Dirty filter monitor for both airstreams.
- 33 C. Carbon Dioxide: Adjustable control from 600 - 2000 PPM for wall mounting with
34 digital display
- 35 D. Factory-installed microprocessor controller and sensors, ERV controls that:

1. Comply with requirements in Division 23 Section "Sequence of Operations for HVAC Controls"
2. The microprocessor controller shall be capable of operating at temperatures between -20F to 160F
3. The microprocessor controller shall be a DIN rail mounting type
4. Factory-installed microprocessor controller shall come with backlit display that allows menu-driven display for navigation and control of unit
5. The microprocessor controller shall have integrated ethernet interface and a web server for displaying unit parameters
6. The microprocessor shall have near field communication (NFC) capability for android devices
7. The microprocessor controller shall have an internal programmable time clock that will allow the user to add up to different occupancy schedules and add holidays
8. The microprocessor control shall be capable of integral diagnostics
9. The microprocessor control shall be capable of IP or SI unit display
10. The microprocessor controller shall have a battery powered clock
11. A remote user terminal to allow for remote monitoring and adjustment of parameters, allowing ease of control access without going outdoors or into the mechanical room if desired by the user
12. The microprocessor controller shall have at a minimum (10) universal inputs/outputs (AI, DI, AO) and have (6) six relay outputs (DO)
13. The microprocessor controller shall have an integrated fieldbus port
14. The microprocessor controller shall have the capability for I/O expansion
15. The microprocessor controller shall have a micro USB port to load the application program, the unit parameters, saving logs, etc.
16. The sensors that will be required for control are:
 - a. (2) Temperature sensor for fresh air and exhaust air
 - b. (2) Temperature and humidity sensor for outside air, return air
 - c. (2) Differential pressure sensors for filter alarms
 - d. (2) Adjustable current switches
17. Field-installed duct or room CO2 sensor The microprocessor controller shall have the capability to monitor the unit conditions for alarm conditions. Upon detecting an alarm, the microprocessor controller shall have the capability to record the alarm description, time, date, available temperatures, and unit status for user review. A digital output shall be reserved for remote alarm indication. Provide the following alarm functions:
 - a. Outside air temperature sensor alarm
 - b. Outside air humidity sensor alarm
 - c. Return air temperature sensor alarm
 - d. Return air humidity sensor alarm
 - e. Fresh air sensor alarm
 - f. Exhaust air sensor alarm
 - g. Dirty filter alarm
 - h. Supply and exhaust air proving alarm

- i. CO2 sensor alarm
18. Display the following on the face of microprocessor controller:
 - a. Unit on
 - b. Outdoor air temperature
 - c. Outdoor air humidity
 - d. Return air temperature
 - e. Return air humidity
 - f. Supply air temperature
 - g. Unit on/off
 - h. Fan on/off
 - i. Damper status
 - j. Alarm digital display
19. The microprocessor controller shall have factory pre-programmed multiple operating sequences for control of the ERV. Factory default settings shall be fully adjustable in the field. Available factory pre-programmed sequences on operations are:

E. SEQUENCE OF OPERATIONS

1. DDC CONTROLLER:
 - a. Controller with integral LCD readout for changing set points and monitoring unit operation.
 - b. Provided with required sensors and programming.
 - c. Factory programmed, mounted, and tested.
 - d. Integral USB and Ethernet ports for updating programs and retrieving log files.

F. GENERAL OPERATION

1. POWER UP:
 - a. When the unit main disconnect is closed a delay of 10 seconds (adjustable) occurs for the controller to come online.

G. ERV UNIT START COMMAND:

1. An input signal is required to enable the unit operation. The unit will be commanded on by:
 - a. Digital input
2. All types of input that are enabled must be true before the unit will start.
 - a. The exhaust fan starts after a 3 second delay (adjustable). The exhaust fan will not start until the damper actuator end switch closes.
 - b. The supply fan starts after a 6 second delay (adjustable). The supply fan will not start until the damper actuator end switch closes.
 - c. The supply fan, exhaust fan, heating are controlled based on the chosen unit operating modes and air conditions.

H. ERV UNIT STOP COMMAND (OR DE-ENERGIZED):

1. The unit can then be commanded off by:

- a. Digital input
2. Supply fan and exhaust fan are de-energized.
3. All dampers are unpowered and spring return to their default position after a 10 second delay (adjustable).

I. SUPPLY FAN OPERATION:

1. The supply fan speed will be controlled for:
 - a. CO₂ flow
2. The unit will attempt to start the supply fan when the supply fan delay timer expires. When the supply fan starts the supply fan adjustable current switch should close and remain closed until the fan is turned off.

J. SUPPLY FAN STATUS:

1. Once the supply fan current switch closes heating operation is allowed. After a delay of 90 seconds (adjustable) from supply fan start signal, if the supply fan current switch is still open the supply fan alarm should be set to true and heating operation shall be prohibited. The supply fan status shall be set to true only when the supply fan output is on and supply fan current switch is closed. The supply fan status shall be false in all other circumstances.

K. CO₂ FLOW CONTROL OPTION:

1. The controller will adjust the supply fan VFD command based on the measured room or return air CO₂ level. The supply air flow set point is derived from the user entered minimum and maximum CO₂ levels and minimum and maximum desired air flow rates. When the CO₂ level is at or below the minimum CO₂ level the air flow set point is at the minimum and when the CO₂ level is at or above the maximum CO₂ level the air flow set point is at the maximum. Between the minimum and maximum CO₂ levels the air flow set point is linearly scaled. If the measured CO₂ level exceeds 1000 ppm (adjustable) for more than 60 seconds (adjustable) a CO₂ alarm will be set to true. This supply fan operation mode can be used to provide demand controlled ventilation of a space. The minimum fan speed will provide the required minimum outdoor air when the CO₂ level is at or below the CO₂ set point.

2.07 FILTER SECTION

- A. ERV shall have 2" thick MERV 8 disposable pleated filters located in the outdoor air and exhaust airstreams. All filters shall be accessible from the exterior of the unit.

PART 3 EXECUTION

3.01 EXAMINATIO

1 A. Prior to start of installation, examine area and conditions to verify correct location
2 for compliance with installation tolerances and other conditions affecting unit
3 performance. See unit IOM.

4 B. Examine roughing-in of plumbing, electrical and HVAC services to verify actual
5 location and compliance with unit requirements. See unit IOM.

6 C. Proceed with installation only after all unsatisfactory conditions have been
7 corrected.

8 3.02 INSTALLATION

9 A. Installation shall be accomplished in accordance with these written specifications,
10 project drawings, manufacturer's installation instructions as documented in
11 manufacturer's IOM, Best Practices and all applicable building codes.

12 B. Install unit with clearances for service and maintenance.

13 3.03 CONNECTIONS

14 A. In all cases, industry Best Practices shall be incorporated. Connections are to be
15 made subject to the installation requirements shown above.

16 B. Duct installation and connection requirements are specified in Division 23 of this
17 document.

18 C. Electrical installation requirements are specified in Division 26 of this document.

19 3.04 FIELD QUALITY CONTROL

20 A. Contractor to inspect field assembled components and equipment installation, to
21 include electrical and piping connections. Report results to Architect/Engineer in
22 writing. Inspection must include a complete startup checklist to include (as a
23 minimum) the following: Completed Start-Up Checklists as found in
24 manufacturer's IOM. Insert any other requirements here.

25 3.05 START-UP SERVICE

26 A. Contractor to perform startup service. Clean entire unit, comb coil fins as
27 necessary, and install clean filters. Measure and record electrical values for
28 voltage and amperage. Refer to Division 23 "Testing, Adjusting and Balancing"
29 and comply with provisions therein.

30 3.06 DEMONSTRATION AND TRAINING

31 A. Contractor to train owner's maintenance personnel to adjust, operate and maintain
32 the entire Make-Up Air unit. Refer to

33
END OF SECTION

SECTION 23 81 27

SPLIT-SYSTEM HEAT PUMP UNITS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.02 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 2. Wiring Diagrams: For power, signal, and control wiring.
- C. Field quality-control reports.
- D. Warranty: Sample of special warranty.
- E. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.03 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.04 COORDINATION

- A. Coordinate sizes and locations of concrete curbs, roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.05 WARRANTY

- A. Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS:

- A. Carrier, Friedrich, Mitsubishi, Samsung, Trane, or approved equal.

2.02 HIGH - WALL, EVAPORATOR-FAN COMPONENTS

A. Cabinet

1. Formed of high strength molded plastic or formed metal with front panel access for filter. Color shall be white. Unit to be mounted to ceiling utilizing factory supplied mounting plate.
2. Indoor unit shall be factory assembled, wired and tested. Contained within the unit shall be all factory wiring and internal piping, control circuit board and fan motor. The unit in conjunction wireless remote controller shall have a self-diagnostic function, 3-minute time delay mechanism, and auto restart function, and a test run switch. Indoor unit and refrigerant pipes shall be purged with dry nitrogen before shipment from the factory.

B. Refrigerant Coil

1. Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.
2. A condensate pan and drain shall be provided under the coil.
3. Provide factory condensate pump accessory.

C. Fan and Motor

1. Centrifugal fan, directly driven by multi-speed, electric motor with integral overload protection; resiliently mounted, and permanently lubricated bearings.

D. Filters

1. Permanent/removable, cleanable.

2.03 AIR-COOLED, COMPRESSOR-CONDENSER COMPONENTS

A. Casing

1. Steel, finished with baked enamel, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.

B. Compressor

1. Hermetically sealed with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
2. Compressor Type: Rotary.
3. Variable Speed – Compressor speed to be driven by inverter circuit. Compressor speed shall dynamically vary to match the room load.

- 1 4. Top prevent liquid from accumulating in the compressor during the off
2 cycle, a minimal amount of current shall be intermittently applied to the
3 compressor motor to maintain enough heat.

4 C. Refrigerant Coil

- 5 1. Copper tube, with mechanically bonded aluminum fins, complying with
6 ARI 210/240, and with liquid subcooler. Refrigerant flow from the
7 condenser shall be controlled by means of linear expansion valve (LEV)
8 metering orifice. The LEV shall be controlled by a microprocessor
9 controlled step motor.

10 D. Fan

- 11 1. Aluminum-propeller type, directly connected to motor.

12 E. Motor

- 13 1. Permanently lubricated, with integral thermal-overload protection.

14 F. Mounting Base

- 15 1. Concrete Pad or wall brackets as indicated on drawings.

16 2.04 ACCESSORIES

- 17 A. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

- 18 B. Automatic-reset timer to prevent rapid cycling of compressor.

- 19 C. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory
20 cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared
21 fittings at both ends.

- 22 D. Condensate pump

23 PART 3 EXECUTION

24 3.01 INSTALLATION

- 25 A. Install units level and plumb.

- 26 B. Install evaporator-fan components using manufacturer's standard mounting
27 devices securely fastened to building structure.

- 28 C. Equipment Mounting:

- 29 1. Install ground-mounted, compressor-condenser components on cast-in-
30 place concrete equipment base(s).
31 2. Install ground-mounted, compressor-condenser components on
32 polyethylene mounting base.

- 1 D. Install and connect precharged refrigerant tubing to component's quick-connect
2 fittings. Install tubing to allow access to unit.

3 3.02 FIELD QUALITY CONTROL

- 4 A. Manufacturer's Field Service: Engage a factory-authorized service representative
5 to inspect, test, and adjust components, assemblies, and equipment installations,
6 including connections.

- 7 B. Tests and Inspections:

- 8 1. Leak Test: After installation, charge system and test for leaks. Repair
9 leaks and retest until no leaks exist.
10 2. Operational Test: After electrical circuitry has been energized, start units
11 to confirm proper motor rotation and unit operation.
12 3. Test and adjust controls and safeties. Replace damaged and
13 malfunctioning controls and equipment.

- 14 C. Remove and replace malfunctioning units and retest as specified above.

- 15 D. Prepare test and inspection reports.

16 3.03 STARTUP SERVICE

- 17 A. Perform startup service.

18 END OF SECTION

SECTION 23 82 00

TERMINAL HEAT TRANSFER UNITS

PART 1 GENERAL

1.01 WORK INCLUDES

- A. Electric Baseboard
- B. Electric Wall Heaters
- C. Electric Duct Reheat Coils

1.02 RELATED WORK

- A. Section 23 05 13 - Motors
- B. Section 23 09 00 - Temperature Controls
- C. Section 23 21 13 - Hydronic Piping

1.03 SUBMITTALS

- A. Submit shop drawings, product data and samples under provisions of Section 23 05 00.

PART 2 PRODUCTS

2.01 ELECTRIC BASEBOARD

- A. Assembly: UL listed and labeled with terminal box and cover, and built-in controls.
- B. Heating Elements: Enclosed steel tube, zinc plated steel finned element of coiled nickel-chrome resistance wire centered in tubes and embedded in refractory material.
- C. Enclosure: Minimum 20 gauge steel with 6-3/4" high back of one piece; front panel, end panel, end caps, corners, and joiner pieces to snap together, and front panel easily removable.
- D. Element Hangers: Quiet operating, cradle type providing unrestricted longitudinal movement, on enclosure brackets.
- E. Control: Wall mounted pneumatic thermostat.
- F. Acceptable Manufacturers:
 - 1. Qmark

- 1 2. Berko
- 2 3. Markel

3 2.02 ELECTRIC WALL HEATERS

- 4 A. Assembly: UL listed and labeled.
- 5 B. Heating Elements: Use corrosion resistant heating elements, designed for even
- 6 distribution of air across the heating element, and installed to prevent noise of
- 7 expansion and contraction.
- 8 C. Provide units with necessary overheat protection, reset devices and contactors.
- 9 D. Fan powered units must be provided with integral thermostat and controls to
- 10 maintain fan operation until residual heat in the heating elements has been
- 11 dissipated. The fans and motors shall be balanced and mounted for vibration free
- 12 operation.
- 13 E. Construct cabinets of 18 gauge steel, furnished exposed cabinets with a baked
- 14 enamel finish in one of the manufacturer's standard color.
- 15 F. Acceptable Manufacturers:
- 16 1. Qmark
- 17 2. Berko
- 18 3. Markel
- 19 4. or approved substitute

20 2.03 ELECTRIC DUCT REHEAT COILS

- 21 A. Manufacturers:
- 22 1. Warren
- 23 2. Indeeco
- 24 3. Redd-2
- 25 4. Markel
- 26 B. Use corrosion resistant heating elements, designed for even distribution of air
- 27 across the heating element, and installed to prevent noise of expansion and
- 28 contraction.
- 29 C. Provide units with necessary overheat protection, reset devices, fuses, staging
- 30 control, contactors, transformers, air flow switch and built-in disconnect switch.
- 31 D. Enclose control components in a totally enclosed aluminized steel terminal box.
- 32 Disconnect switch shall be interlocked with terminal box door.

33 PART 3 EXECUTION

34 3.01 INSTALLATION

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